Progress Energy

Serial: NPD-NRC-2009-222
November 2, 2009

10CFR52.79

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555-0001

LEVY NUCLEAR PLANT, UNITS 1 AND 2
DOCKET NOS. 52-029 AND 52-030
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 046 RELATED TO SEISMIC DESIGN PARAMETERS

Reference: Letter from Chandu P. Patel (NRC) to Garry Miller (PEF), dated May 20, 2009, "Request for Additional Information Letter No. 046 Related to SRP Section 3.7.1 for the Levy County Nuclear Plant Units 1 and 2 Combined License Application"

Ladies and Gentlemen:

Progress Energy Florida, Inc. (PEF) hereby submits our response to the Nuclear Regulatory Commission's (NRC) request for additional information provided in the referenced letter.

A response to the NRC request is addressed in the enclosure. The enclosure also identifies changes that will be made in a future revision of the Levy Nuclear Plant Units 1 and 2 application.

If you have any further questions, or need additional information, please contact Bob Kitchen at (919) 546-6992 or me at (727) 820-4481.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on November 2, 2009.

Sincerely,

John Elnitsky
Vice President
Nuclear Plant Development

Enclosure/Attachments

cc : U.S. NRC Region II, Regional Administrator
Mr. Brian C. Anderson, U.S. NRC Project Manager

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Levy Nuclear Plant Units 1 and 2
Response to NRC Request for Additional Information Letter No. 046 Related to SRP Section 3.7.1 for the Combined License Application, dated May 20, 2009

NRC RAI #	Progress Energy RAI #	Progress Energy Response
03.07.01-1	L-0207	Response enclosed – see following pages

NRC Letter No.: LNP-RAI-LTR-046

NRC Letter Date: May 20, 2009

NRC Review of Final Safety Analysis Report

NRC RAI NUMBER: 03.07.01-01

Text of NRC RAI:

Levy FSAR Section 3.7.1.1.2 states that the foundation input response spectra (FIRS) which are based on the site-specific ground motion response spectra (GMRS), are considered in site-specific response analysis. It is further stated that the resulting Levy FIRS are exceeded by the AP1000 CSDRS spectra by a factor greater than 3 in both the horizontal and vertical directions over the entire frequency range of interest. It is concluded in this Section that this large margin of exceedance is sufficient to preclude any uncertainties associated with the effects of adjacent structures supported on drilled shafts.

It is important to point out that the FIRS and the CSDRS are defined at different elevations and, therefore, cannot be compared directly. The process requires that deterministic site-specific calculations be performed to generate the ground motions (both horizontal and vertical) at plant grade for each of the three soil columns used in the SSI calculation (BE, UB and LB site profiles in accordance with SRP Section 3.7.2 –II. Acceptance Criteria). The comparison that needs to be made is then the CSDRS for AP1000 with the envelope of the spectra generated at the ground surface for each of the three SSI profiles. The use of the FIRS in this comparison is inappropriate.

Figures 2.5.2-247 & -248 show that discreet shear wave velocities as measured by the P-S logger are quite variable, ranging by wide margins from the average value within the zone of influence. This puts into question the degree of variability assumed in the SSI calculations, the assumption of uniformity of properties within a given layer if voids filled with soft soil are present within the same rock stratum, and the impact of potential variability in layer properties across the footprint of the NI on SSI response.

Finally, the design of the NI structures are based on the intrinsic assumption that the properties of the soils to the side of the structure are the same as under the foundation and that the seismic gap between the NI and adjacent facilities is adequate to account for the relative displacements anticipated for the plant. The behavior of the adjacent structures under seismic loading is directly related to the design of the drilled shafts supporting these structures as well as the support these soils can provide to the drilled shafts.

Please provide justification for the assumed uniformity of layer structure for SSI response evaluations and potential impact of loss of support of side soils on drilled shaft design in case of Levy site.

PGN RAI ID #: L-0207

PGN Response to NRC RAI:

Site-specific surface response spectra at finished grade elevation 15.5 m (51 ft.) NAVD88, along with associated soil column outcrop response (SCOR) foundation input response spectra (FIRS) were developed for response to this RAI and will be incorporated into the FSAR. The GMRS discussed in the FSAR was developed as the Truncated Soil Column Surface Response

(TSCSR) on the uppermost in-situ competent material at elevation 11 m (36 ft.) NAVD88 as described in Subsection 2.5.2.6. Since plant finished grade will be established at elevation 15.5 (51ft) NAVD88 by engineered fill above in-situ material as noted in Subsection 2.5.4.5, performance based surface horizontal and vertical response spectra (PBSRS) at the finished grade were developed using the same methodology and in-situ soil properties used for developing the GMRS described in Subsection 2.5.2.6. Engineered fill properties presented in Revised Table 2.5.4.5-201 were used from elevation 11 m (36 ft.) NAVD88 to elevation 15.5 m (51 ft.) NAVD88 in the response analysis. The vertical and the horizontal PBSRS were scaled by a factor required for the horizontal free-field soil column outcrop response (SCOR) spectra at the AP1000 foundation elevation 3.4 m (11 ft.) NAVD88 to meet the 0.1g zero period acceleration (ZPA) requirement of 10 CFR Part 50 Appendix S. The scaled horizontal and vertical SCOR FIRS at the AP1000 foundation elevation 3.4 m (11 ft.) NAVD88 are shown in RAI 03.07.01-01 Figure 19. RAI 03.07.01-01 Table 1 presents the digitized scaled horizontal and vertical PBSRS and RAI 03.07.01-01 Figure 1 presents the comparison of the AP1000 CSDRS with the scaled PBSRS for horizontal and vertical ground motions. The CSDRS envelops the PBSRS for both the horizontal and the vertical ground motions by a significant margin.

The top of the basemat for the Annex Building, Radwaste Building, and the Turbine Building (except for the condenser pit area) is at finished grade elevation 15.5 m (51 ft.) NAVD88 (Subsection 2.5.4.3). The PBSRS will be used to compute the maximum relative displacements between the Nuclear Island and the Annex Building, Turbine Building, and the Radwaste Building drilled shaft foundation to evaluate site-specific aspect of the seismic II/I interaction of these buildings with the Nuclear Island. See response to RAI 03.08.05-3.

In addition to the PBSRS, finished grade Soil Structure Interaction (SSI) analysis input surface spectra were developed using Section 5.2.1 of the Interim Staff Guidance DC/COL-ISG-017 as described in revised Subsection 2.5.2.6. The finished grade surface response spectra from the three soil columns (best estimate, lower bound, and the upper bound properties) were developed using SCOR FIRS developed for elevation -7.3 m (-24 ft.) NAVD88, the base of planned excavation beneath the nuclear island. This FIRS was scaled to ensure that the computed SCOR at the AP1000 foundation elevation 3.4 m (11 ft.) NAVD88 meets the 0.1g minimum ZPA requirement of 10 CFR Part 50 Appendix S. The discussion of FIRS development in Subsection 2.5.2.5 of the FSAR will be revised to describe the updated approach and results. Three soil property profiles for SSI input were developed based on the variation in the randomized soil profiles used for developing PBSRS and complying with SRP 3.7.2.II.4 guidance on soil property variation for SSI analysis. The shear wave velocity profiles for the upper bound (UB), best estimate (BE) and lower bound (LB) soil profiles are shown in RAI 03.07.01-01 Figure 2. The soil column profile and soil properties are presented in RAI 03.07.01-01 Tables 2, 3, and 4 for BE, LB, and UB cases respectively. Horizontal and vertical SSI input acceleration time histories were developed by spectral matching to the SCOR FIRS developed for elevation -7.3 m (-24 ft.) NAVD88. The spectral matching was performed using the criteria presented in McGuire et al. 2001 (/NUREG/CR-6728). The target scaled FIRS at elevation -7.3 m (-24 ft.) NAVD88 were modified to ensure that the computed surface motions using the three SSI velocity profiles envelop the PBSRS. Revised Figure 3.7.1-201 shows the scaled and modified SCOR FIRS at elevation -7.3 m (-24 ft.) NAVD88. RAI 03.07.01-01 Figures 20, 21, and 22 show the resulting time histories. The SSI input spectra from the UB, BE, and LB soil columns (RAI 03.07.01-01 Figures 3, 4 and 5) along with the corresponding acceleration time histories and corresponding UB, BE, and LB soil column profiles (RAI 03.07.01-01 Tables 2, 3, and 4) would be used for Nuclear Island SSI analysis, if required. The envelope of the SSI input spectra from the UB, LB, and BE envelops the PBSRS as required by DC/COL-ISG-017. RAI 03.07.01-01 Figures 3 and 4 present the comparison of the AP1000 CSDRS with the SSI

input response spectra from the UB, BE, and LB soil columns for the horizontal ground motions for the North-South (H1) and the East-West (H2) directions. The CSDRS envelops the SSI input response spectra from the three soil columns. Thus, site specific SSI analysis for horizontal ground motions is not required.

For the vertical ground motions, RAI 03.07.01-01 Figure 5 presents the comparison of the AP1000 CSDRS with the scaled PBSRS and the SSI input response spectra from the three soil columns. The CSDRS envelops the scaled vertical PBSRS by a similarly large margin as the horizontal. However, it does not envelop the finished grade surface SSI input response spectra from the three soil columns in the high frequency range (greater than approximately 30 Hz). For the vertical direction, the response at the top of the free field soil columns overestimates amplification that will be experienced by the AP1000. This is due to the fact that the AP1000 mat for LNP is supported vertically on the 35' thick roller compacted concrete (RCC) mat that rests on rock. Amplification of the vertical motion to the AP1000 mat will be minimal because of the high shear wave (3500 ft/sec) velocity through the RCC mat. As shown in Figure 3.7.1-201 the vertical CSDRS envelops the scaled vertical FIRS at the base of the excavation by a large margin. Based on this large margin and the minimal amplification expected through the RCC mat, CSDRS-based vertical in-structure spectra is judged to envelop the corresponding site-specific FIRS-based in-structure spectra.

Consideration of the variability of shear wave velocities as measured by the P-S Suspension logger (Figures 2.5.2-247 and -248) on the site response calculations using the SHAKE program and the justification of using uniform layers was presented in response to LNP-RAI-LTR-031, RAI 02.05.02-3. The same justification is applicable to the modeling of soil layers for SSI response evaluations. The RAI 02.05.02-3 RAI response concluded "In summary, the LNP site consists of generally flat-lying layers suitable for 1-D site response. Variability in layer velocity for an individual unit obtained using the same measurement technique exhibited typical variability, which was modeled by velocity randomization. Variability between the average velocities at the two units and between results for different measurement techniques at a single unit was captured by developing multiple base-case profiles and then enveloping the site response amplification functions." Note that the process used of randomization about multiple base cases captured the range in assigned layer velocities shown on Figures 2.5.2-247 and 2.5.2-248.

The AP1000 generic soil profiles (APP-GW-GLR-044 Revision 1 (TR-85) submitted by Westinghouse Electric Corporation on February 02, 2009) include profiles where properties of soils to the side of the structure are lower than those under the foundation (APP-GW-GLR-044 Revision 1 Figure 2.4-3 "Soft to Med" and "Soft to Med UB" soil profiles). The variation of shear wave velocity with depth at the LNP site is similar to the "Soft to Med UB" soil case in LNP site in APP-GW-GLR-044 Revision 1. The AP1000 generic soil profiles also include profiles where properties of soils to the side of the structure are approximately the same as those under the foundation (APP-GW-GLR-044 Revision 1 Figure 2.4-3 "Soft Soil", "Soft Rock", "Firm Rock", and "Hard Rock" profiles).

The design of the adjacent structures (Turbine Building, Annex Building, and Radwaste Building) and their drilled shaft foundation is in progress. Response to LNP-RAI-LTR-055, RAI 03.08.05-3 will provide lateral displacements of the drilled shaft supported Turbine Building, Annex Building, and Radwaste Building foundations and evaluate the site-specific aspects of the seismic II/I interaction of these buildings with the Nuclear Island. The RAI response will also describe the methodology and soil properties used for calculating the lateral displacements for the drilled shaft supported foundations for these buildings.

Associated LNP COL Application Revisions:

The following changes will be made to Subsections 2.5 and 3.7 of the FSAR in a future revision:

1) Text changes to Subsection 2.5.0, 2.5.2, 2.5.4, and 3.7.1 as noted below;

2) Figures will be replaced and added to Subsections 2.5.2 and 3.7.1 and as noted below;

3) Table 2.5.4.5-201 will be revised and four new Tables added to Subsection 2.5.2 (RAI 03.07.01-01 Tables 1 through 4) as noted below; and

4) Three new references will be added to Subsection 2.5.2 as noted below.

Text changes:

Subsection 2.5.0 Changes

The last paragraph of 2.5.0.2.5 will be modified from:

"The site response analyses profiles for the base of excavation foundation input response spectra (FIRS) calculations were developed by removing all of the layers above elevation –7.3 m (–24 ft.) NAVD88 from the GMRS profiles."

To read:

"The site response analyses profiles for the finished grade case were developed by adding a layer of engineered fill to the GMRS profiles to bring the top elevation up to 15.5 m (51 ft.) NAVD88. The analyses were performed for a wide range of engineered fill properties."

A new paragraph will be added to the end of Subsection 2.5.0.2.6:

"Performance based surface response spectra (PBSRS) and associated soil column outcropping response (SCOR) foundation input response spectra (FIRS) were developed using the site response analysis of profiles that extended to the finished grade elevation. These spectra were scaled upward in order to meet the requirement of a minimum peak horizontal acceleration of 0.1g at the reactor foundation level. These spectra are used to develop inputs for soil structure interaction (SSI) analyses. The scaled PBSRS are also enveloped by the Westinghouse CSDRS. In addition, finished grade (elevation 15.5 m [51 ft.]) SSI input response spectra were developed. Three SSI input soil profiles were developed from the randomized soil profiles used to compute the PBSRS. These profiles accommodate the variability in the in-situ materials and the anticipated range in fill properties."

Subsection 2.5.2 Changes

A new paragraph will be added to the end of Subsection 2.5.2.5 before the beginning of Subsection 2.5.2.5.1:

"Two sets of site amplification functions were developed. The first set was used to develop the site Ground Motion Response Spectra (GMRS) following guidance given in Regulatory Guides 1.165 and 1.208. The second set was used to develop the site Performance Based Surface Response Spectra (PBSRS) and associated Foundation Input Response Spectra (FIRS) for use in potential Soil Structure Interaction (SSI) analyses. This second set of amplification functions was developed following Subsection 5.2.1 of the Interim Staff Guidance DC/COL-ISG-

017. The process used to develop the PBSRS and FIRS follows that given above for the GMRS. The primary difference is that the PBSRS is developed for the plant finished grade and includes the effects of engineered fill that raises nominal site grade from approximately +12.8 m (+42 ft.) to +15.5 m (+51 ft.) NAVD88."

The last paragraph of Subsection 2.5.2.5.1.1 will be modified from:

"Regulatory Guide 1.208 indicates that the site-specific GMRS should be defined at the ground surface or at the top of the first competent layer. Given that the upper Quaternary sands have low velocity and are to be removed during construction (FSAR Subsection 2.5.4.5), the reference point for the GMRS is taken to be the top of the calcareous silt (unit S2, weathered limestone) at an average elevation of 11 m (36 ft.) NAVD88. The planned construction approach for the units (FSAR Subsection 2.5.4.5) calls for excavation of the undifferentiated Quaternary/Tertiary sediments (S1, S2, and S3) to an average elevation of –7 m (–24 ft.) NAVD88, which is the top of the Avon Park Formation. Evaluation of the seismic response of the safety-related structures would require FIRS at this location."

To read:

"Regulatory Guide 1.208 indicates that the site-specific GMRS should be defined at the ground surface or at the top of the first competent layer. Given that the upper Quaternary sands have low velocity and are to be removed during construction (FSAR Subsection 2.5.4.5), the reference point for the GMRS is taken to be the top of the calcareous silt (unit S2, weathered limestone) at an average elevation of 11 m (36 ft.) NAVD88. The planned construction approach for the units (FSAR Subsection 2.5.4.5) calls for excavation of the undifferentiated Quaternary/Tertiary sediments (S1, S2, and S3) to an average elevation of –7 m (–24 ft.) NAVD88, which is the top of the Avon Park Formation. Evaluation of the seismic response of the proposed safety-related structures would require FIRS at this location. FIRS are also developed at the reactor foundation elevation of +3.3m (+11 ft) NAVD88 for the purpose of checking the requirement of the minimum level of ground motion specified in Subsection 3.7.1 of the Standard Review Plan.

As described in FSAR Subsection 2.5.4.5, engineered fill will be placed to raise the site elevation to +15.5 m (+51 ft.) NAVD88. The anticipated average shear wave velocity of the engineered fill is in the range of 152 to 305 m/sec (500 to 1000 ft/sec) with a best estimate value of 259 m/sec (850 ft/sec) as shown in Table 2.5.4.5-201."

The following sentence will be added to end of the first paragraph of Subsection 2.5.2.5.1.3:

"The expected unit weight of the engineered fill is 110 pcf as shown in Table 2.5.4.5-201."

The following paragraph will be added to the end of Subsection 2.5.2.5.1.4:

"Shear modulus reduction and damping relationships for the engineered fill material to be placed at the site were estimated based on the work of Darendeli (Reference RAI 03.07.01-01 01) and Menq (Reference RAI 03.07.01-01 02) and the anticipated range of engineered fill materials that may be used (Table 2.5.4.5-201). RAI 03.07.01-01 Figure 6 shows the range of shear modulus relationship developed from the published literature using the range of engineered fill properties. The relationships developed from Menq (Reference RAI 03.07.01-01 02) for granular fill are the most conservative in that they contain less modulus reduction and

lower damping. These relationships were selected to model the nonlinear properties of the engineered fill."

The last paragraph of Subsection 2.5.2.5.1.5 will be changed from:

"These results indicate that at each unit the amplification for one profile essentially envelops the amplification from the other. The highest amplification for LNP 1 is obtained for profile LNP 1 P2 and the highest amplification for LNP 2 is obtained for profile LNP 2 P1. These two profiles were selected for calculation of the site amplification for the GMRS motions. The profile for LNP 1 is designated GMRS profile LNP 1 and the profile for LNP 2 is designated GMRS profile LNP 2. These velocity profiles are plotted on Figure 2.5.2-254 and are listed in Tables 2.5.2-222 and 2.5.2-223. The site response analyses profiles for the base of excavation FIRS calculations were developed by removing all of the layers above elevation -24 ft from the GMRS profiles."

To read:

"These results indicate that at each unit the amplification for one profile essentially envelops the amplification from the other. The highest amplification for LNP 1 is obtained for profile LNP 1 P2 and the highest amplification for LNP 2 is obtained for profile LNP 2 P1. These two profiles were selected for calculation of the site amplification for the GMRS motions. The profile for LNP 1 is designated GMRS profile LNP 1 and the profile for LNP 2 is designated GMRS profile LNP 2. These velocity profiles are plotted on Figure 2.5.2-254 and are listed in Tables 2.5.2-222 and 2.5.2-223.

The site response analyses profiles for the PBSRS were developed by adding a layer of engineered fill to the GMRS profiles to bring the surface elevation to +15.5 m (+51 ft.) NAVD88. Analyses were performed using engineered fill velocities of 152 m/sec (500 ft/sec), 259 m/sec (850 ft/sec), and 305 m/sec (1000 ft/sec) (Table 2.5.4.5-201)."

The last two paragraphs of Subsection 2.5.2.5.1.6 will be modified from:

"The modulus reduction and damping relationships were also randomized, as shown on Figures 2.5.2-261, 2.5.2-262, 2.5.2-263, 2.5.2-264, 2.5.2-265, and 2.5.2-266. The standard deviation in the modulus reduction and damping were set so that the randomized relationships fell within recommended bounds provided by Silva (Reference 2.5.2-273). The damping ratio curves were limited to a maximum of 15 percent damping as recommended in Appendix E of Regulatory Guide 1.208.

The damping in the sedimentary rocks beneath the soil profile was also randomized in the analysis. The standard deviation of $\ln(\kappa)$ was set equal to 0.3, consistent with the variability in κ used in McGuire et al. and EPRI (Reference 2.5.2-263, Reference 2.5.2-274). The appropriate damping ratio in the sedimentary rock layers was then computed using the randomized sedimentary rock layer velocities and thicknesses and the randomly selected value of κ. Statistics of the resulting values of material damping assigned to the linear rock layers are given in Table 2.5.2-224.

To read:

"The modulus reduction and damping relationships were also randomized, as shown on Figures 2.5.2-261, 2.5.2-262, 2.5.2-263, 2.5.2-264, 2.5.2-265, 2.5.2-266, and RAI 03.07.01-01 Figure 7. The standard deviation in the modulus reduction and damping were set so that the randomized relationships fell within recommended bounds provided by Silva

(Reference 2.5.2-273). The damping ratio curves were limited to a maximum of 15 percent damping as recommended in Appendix E of Regulatory Guide 1.208.

The damping in the sedimentary rocks beneath the soil profile was also randomized in the analysis. The standard deviation of ln(κ) was set equal to 0.3, consistent with the variability in κ used in McGuire et al. and EPRI (Reference 2.5.2-263, Reference 2.5.2-274). The appropriate damping ratio in the sedimentary rock layers was then computed using the randomized sedimentary rock layer velocities and thicknesses and the randomly selected value of κ. Statistics of the resulting values of material damping assigned to the linear rock layers are given in Table 2.5.2-224.

Similar sets of randomized profiles were developed for the six PBSRS analysis cases (two site profiles times three engineered fill velocities)."

Subsection 2.5.2.5.3.2 will be modified from:

"2.5.2.5.3.2 Site Amplification Functions for FIRS Profiles

The process described above for developing the GMRS profile amplification functions was repeated for the base of excavation FIRS profiles. The analyses were performed with all material above elevation -7.3 m (-24 ft.) NAVD88 removed.

Figures 2.5.2-281 and 2.5.2-282 compare the mean site amplification functions for the two FIRS profiles for 10^{-4} and 10^{-5} input ground motions, respectively. The difference in response is similar to that found for the GMRS profiles. Consistent with the GMRS analysis, a single envelope amplification function is developed for the two ground motion levels. The results are plotted on Figure 2.5.2-283.

The base of excavation FIRS amplification is much less sensitive to the ground motion level because the only material considered to behave nonlinearly occurs at depth in the low-velocity layer between elevation -48.8 to -67.1 m (-160 and -220 ft.) NAVD88. The envelope amplification functions are again smoothed by eye and the resulting smoothed envelope amplification functions are plotted on Figure 2.5.2-284."

To read:

"2.5.2.5.3.2 Site Amplification Functions for PBSRS Profiles

The process described above for developing the GMRS profile amplification functions was repeated for the finish grade PBSRS profiles.

Figures 2.5.2-281 and 2.5.2-282 compare the mean site amplification functions for the two PBSRS profiles for a engineered fill velocity of 259 m/sec (850 ft/sec) and 10^{-4} and 10^{-5} input ground motions, respectively. The difference in response is similar to that found for the GMRS profiles. The amplification functions for engineered fill velocities of 152 m/sec (500 ft/sec) and 305 m/sec (1000 ft/sec) also show similar results for the two LNP profiles. Consistent with the GMRS analysis, a single envelope amplification function is developed for each ground motion level. The results are plotted on Figure 2.5.2-283a, Figure 2.5.2-283b, and Figure 2.5.2-283c for engineered fill velocities of 152 m/sec (500 ft/sec), 259 m/sec (850 ft/sec), and 305 m/sec (1000 ft/sec), respectively.

The PBSRS amplifications are more sensitive to the ground motion level because of the nonlinear behavior of the engineered fill materials, especially the lower velocity case. The envelope amplification functions are again smoothed by eye and the resulting smoothed envelope amplification functions are plotted on Figure 2.5.2-284a, Figure 2.5.2-284b, and 2.5.2-

284c. Amplification functions are created for each engineered fill velocity because the difference in response over the range of engineered fill velocity produces different behavior when assessing the probabilistic surface response spectra."

The last paragraph of Subsection 2.5.2.6.1 will be changed from:

"Similar operations were performed to develop surface spectra for the 10^{-5} and 10^{-6} exceedance level motions. This smooth envelope spectrum represents the surface UHRS for the site defined as a free field outcropping motions at elevation 11 m (36 ft.) NAVD88."

To read:

"Similar operations were performed to develop GMRS surface spectra for the 10^{-5} and 10^{-6} exceedance level motions. This smooth envelope spectrum represents the surface UHRS for the site defined as free field surface motions for a soil column truncated at elevation 11 m (36 ft.) NAVD88, the top of the first competent layer.

The above process was followed to develop finished grade surface response spectra at elevation 15.5 m (51 ft.) NAVD88. For this case a weighted combination of the amplification functions for the three engineered fill velocities was used to construct a single surface spectrum for each level of input ground motion. The range in engineered fill velocity provided in Table 2.5.4.5-201 was treated as representing the 90 percent confidence interval for the epistemic uncertainty on the average engineered fill velocity. The three-point distribution developed by Keefer and Bodily (Reference 2.5.2-278) is used to represent the uncertainty distribution, leading to a three-point distribution of 500 ft/sec (weight 0.185), 850 ft/sec (weight 0.63), and 1000 ft/sec (weight 0.185)."

The following two paragraphs will be added to the end of Subsection 2.5.2.6.2:

"CAV hazard calculations were also performed for the finished grade PBSRS profiles. Because of the differences in response among the three engineered fill velocity cases, surface hazard curves were computed individually for the three engineered fill velocities. RAI 03.07.01-01 Figure 8, Figure 9, Figure 10, Figure 11, Figure 12, Figure 13 and Figure 14 show the PBSRS surface hazard curves computed with and without CAV. The difference in behavior among the three engineered fill velocities can be seen. The results for the 139 m/sec (500 ft/sec) engineered fill show greater amplification than the results for the other engineered fill velocities at low ground motion levels due to the larger velocity impedance contrast between the engineered fill and the underlying native materials. At high ground motions, the lower engineered fill velocity produces lower amplification due to greater strain levels induced in this material.

Composite mean hazard curves were computed as a weighted combination of the hazard curves for each engineered fill velocity using the weights assigned above of 0.185 for 500 ft/sec, 0.63 for 850 ft/sec, and 0.185 for 1000 ft/sec. The resulting composite mean hazard curves are shown on RAI 03.07.01-01 Figure 8, Figure 9, Figure 10, Figure 11, Figure 12, Figure 13 and Figure 14. These mean hazard curves were used to obtain CAV/no-CAV spectral ratios at the seven spectral frequencies. These CAV/no-CAV ratios are then used to scale the smooth finished grade surface spectra described in FSAR Subsection 2.5.2.6.1 to produce hazard-consistent mean finished grade surface UHRS that are based on the use of the CAV filter. The CAV/no-CAV spectral ratios at intermediate periods are obtained by log-log interpolation. RAI 03.07.01-01 Figure 15 shows the resulting mean 10^{-4} and 10^{-5} surface UHRS

for the LNP site. Unlike the GMRS profile analysis, the greater amplification of the PBSRS profile results in CAV hazard results for an annual exceedance frequency of 10^{-4}."

The third paragraph in Subsection 2.5.2.6.4 will be changed from:

"Accordingly, an intermediate V/H ratio was developed for the LNP site by first shifting the WUS and CEUS V/H amplitudes to an intermediate frequency and then averaging their amplitudes. The best estimate value of κ for the LNP site is intermediate between the WUS and CEUS values. The WUS and CEUS V/H shapes were thus shifted to a frequency midway in log space between the two. The resulting V/H ratio is shown on Figure 2.5.2-294. In computing the intermediate V/H, a minimum value of 0.5 was used for the WUS V/H ratios to make them consistent in shape to the CEUS V/H ratios. A vertical GMRS was then computed by multiplying the horizontal GMRS by this V/H ratio. The resulting vertical GMRS is listed in Table 2.5.2-226 along with the values of V/H."

To read:

"Accordingly, an intermediate V/H ratio was developed for the LNP site by first shifting the WUS and CEUS V/H amplitudes to an intermediate frequency and then averaging their amplitudes. The best estimate value of κ for the LNP site is intermediate between the WUS and CEUS values. The WUS and CEUS V/H shapes were thus shifted to a frequency midway in log space between the two. The resulting V/H ratio is shown on Figure 2.5.2-295. In computing the intermediate V/H, a minimum value of 0.5 was used for the WUS V/H ratios to make them consistent in shape to the CEUS V/H ratios. A vertical GMRS was then computed by multiplying the horizontal GMRS by this V/H ratio. The resulting vertical GMRS is listed in Table 2.5.2-226 along with the values of V/H."

The title of Subsection 2.5.2.6.5 will be changed from:

"2.5.2.6.5 Comparison of CSDRS"

To read:

"2.5.2.6.5 Comparison of GMRS with CSDRS"

Two new subsections will be added as follows:

"2.5.2.6.6 PBSRS and FIRS

Following the guidance given in Section 5.2.1 of the Interim Staff Guidance DC/COL-ISG-017, a horizontal PBSRS is developed from the finished grade UHRS shown on RAI 03.07.01-01 Figure 15 by applying the relationships described in Subsection 2.5.2.6.3. RAI 03.07.01-01 Figure 16 shows the resulting PBSRS spectra. At frequencies above about 1 Hz the PBSRS is controlled by the 10^{-4} UHRS multiplied by the design factor (DF). At lower frequencies the PBSRS is controlled by 0.45 times the 10^{-5} UHRS.

Subsection 5.2.1 of the Interim Staff Guidance DC/COL-ISG-017 procedure was then followed to develop soil-structure interaction (SSI) input time histories and soil profiles. The first step was to construct a FIRS at the appropriate foundation elevation by extracting ground motions as outcropping motions from the full column site response analyses used to develop the PBSRS. These outcropping motions are used to construct amplification functions that are in turn used to construct a soil column outcropping response (SCOR) FIRS for use in developing input time histories. As the site is to be excavated to an elevation of -7 m (–24 ft.) NAVD88 and the

reactor placed on approximately 10.7 m (35 ft.) of concrete backfill, the appropriate point for placing the input motion is at the base of the excavation. Therefore, a SCOR FIRS was developed for elevation –7 m (–24 ft.) NAVD88. In addition, a SCOR FIRS was developed at the reactor foundation elevation of +3.3m (+11 ft) NAVD88 for the purpose of checking the requirement of the minimum level of ground motion specified in 10 CFR Part 50 Appendix S. The peak ground acceleration of the reactor foundation elevation SCOR FIRS was computed to be 0.0825g. In order to meet the minimum ground motion requirement of 0.1g peak horizontal acceleration at the foundation elevation specified in 10 CFR Part 50 Appendix S., the site PBSRS and SCOR FIRS were scaled by the factor of 0.1/0.0825. RAI 03.07.01-01 Table 1 lists the resulting scaled horizontal PBSRS. The scaled PBSRS is compared to the Westinghouse CSDRS (Reference 2.5.2-273) on RAI 03.07.01-01 Figure 1. The scaled horizontal PBSRS is enveloped by the CSDRS.

The vertical PBSRS was constructed using V/H spectral ratios. The PBSRS profile consists of a thin layer of soil over rock. This condition is somewhat different than the generic rock conditions for which the V/H ratios shown on Figure 2.5.2-295 were developed. The PEER NGA project (Reference RAI 03.07.01-01 03) developed a large database of strong motion recordings with documentation of the site conditions. A set of 108 recordings were selected from the PEER NGA database for the following conditions:

- Peak ground acceleration < 0.2g
- Depth to V_S of 1 km/sec < 100 m to obtain records on rock and shallow soil sites
- Lowpass filter used in record processing ≥ 20 Hz to obtain V/H values at moderately high frequencies.
- Vertical component available from the PEER NGA database.

These data were used to compute average V/H ratios for rock sites and shallow soil sites. RAI 03.07.01-01 Figure 17 shows the updated WUS V/H ratios for rock and shallow soil sites suggested by these data. The updated WUS rock V/H ratios are somewhat lower that those given in McGuire et al. (Reference 2.5.2-263). This may be due in part to a larger data set of small shaking level recordings and in part due to separation of the sites into rock and shallow soil. The empirical ground motion models used by McGuire et al. (Reference 2.5.2-263) to develop their recommended WUS rock V/H ratios contained a mixture of rock and shallow soil sites. As indicated on RAI 03.07.01-01 Figure 17, the V/H ratios for shallow soil sites are somewhat higher than those for rock sites in the region of the peak in the spectral ratios.

The updated WUS spectral ratios shown on RAI 03.07.01-01 Figure 17 were used to construct V/H ratios to develop the vertical PBSRS. First, rock V/H ratios for an intermediate κ value was constructed in the same manner as described in Subsection 2.5.2.6.4. This updated intermediate rock site V/H ratios are shown on RAI 03.07.01-01 Figure 18. Then the ratio of the shallow soil to rock V/H values shown on RAI 03.07.01-01 Figure 17 was used to scale the intermediate rock V/H ratios to account for the effects of the shallow soil (fill). The resulting intermediate shallow soil V/H ratios are shown on RAI 03.07.01-01 Figure 18. The intermediate shallow soil V/H ratios were then multiplied by the scaled horizontal PBSRS to produce the scaled vertical PBSRS. The vertical scaled PBSRS is shown on RAI 03.07.01-01 Figure 1. The vertical scaled PBSRS is enveloped by the Westinghouse CSDRS (Reference 2.5.2-273).

The SCOR FIRS developed for elevation –7 m (–24 ft.) NAVD88 is shown on FSAR Figure 3.7.1-201. These FIRS have been modified (enhanced) at intermediate frequencies to insure that the surface response spectra computed using the three site velocity profiles developed for SSI analyses envelop the PBSRS.

2.5.2.6.7 Site Profiles for SSI Analysis

Soil profiles for use in SSI analyses were developed from the PBSRS site response analyses following the requirements of the Standard Review Plan and guidance given in Section 5.2.1 of the Interim Staff Guidance DC/COL-ISG-017. These profiles were based on the statistics of the iterated soil properties for the randomized site profiles used to develop the PBSRS. The best estimate profile was set equal to values interpolated between the median iterated soil properties for the 10^{-4} and 10^{-5} ground motion level input cases using the ratio of the GMRS peak ground acceleration to the peak acceleration for the 10^{-4} and 10^{-5} UHRS. The resulting site profile is listed in RAI 03.07.01-01 Table 2. The lower bound profile was set equal to the 16th percentile of the distribution of randomized soil properties for the 500 ft/sec engineered fill velocity case and the upper bound profile was set equal to the 84th percentile of the distribution of randomized soil properties for the 1000 ft/sec engineered fill case. The range in the upper bound and lower bound shear wave velocities was increased where necessary to maintain the minimum coefficient of variation in shear modulus of 1.5. RAI 03.07.01-01 Tables 3 and 4 list the lower bound and upper bound profile properties, respectively. RAI 03.07.01-01 Figure 2 shows the top 500 feet of the three shear wave velocity profiles. The corresponding damping ratios were obtained from the statistics of the iterated profiles assuming negative correlation between shear wave velocity and damping: that is the 16th percentile damping was used for the upper bound profile and the 84th percentile damping was used for the lower bound profile. The compression wave velocities were based on the measured values for the in-situ materials and the recommend Poisson's ratio of 0.3 for the engineered fill (Table 2.5.4.5-201). The compression wave velocity of water, set to a nominal value of 5000 ft/sec, was used as a minimum value for the compression wave velocities of materials below the water table."

The following text will be inserted in FSAR Subsection 2.5.4.5.4 following the bulleted list that follows the paragraph "Table 2.5.4.5-201 is a summary of the anticipated engineering properties for each backfill type. The characteristics and use of the materials described in Table 2.5.4.5-201 are as follows:":

- Engineered fill. Engineered fill will be used to raise the site grade to elevation 15.5 m (51 ft.) NAVD88.

Revise the following text in FSAR Table 2.5.4.5-201 from:

Table 2.5.4.5-201
Engineering Properties of Structural Fill and Backfill

	AS-PLACED ENGINEERING PROPERTIES[a]	
Backfill Type	**Strength Parameters**	**V_S (fps)**
Roller Compacted Concrete Bridging Mat	1-Year Compressive Strength: 2500 psi	3500 fps
Concrete Backfill[b]	28-Day Compressive Strength: 500 psi	1000 fps

Notes:

a) These engineering properties are considered representative values of the concrete backfill.

b) Values are typical for concrete backfill, conservatively based on ACI-229R-99.

V_s = Shear Wave Velocity

psi = pound per square inch

fps = foot per second

To read:

Table 2.5.4.5-201

Engineering Properties of Structural Fill and Backfill

	AS-PLACED ENGINEERING PROPERTIES[a]	
Backfill Type	**Strength Parameters**	**V_S (fps)**
Roller Compacted Concrete Bridging Mat	1-Year Compressive Strength: 2500 psi	3500 fps
Concrete Backfill[b]	28-Day Compressive Strength: 500 psi	1000 fps
Engineered fill[c]	Drained friction angle of 33 degrees (or equivalent shear strength); SM-SC USCS Classification	850[d] fps

Notes:

a) These engineering properties are considered representative values of the backfill type.

b) Values are typical for concrete backfill, conservatively based on ACI-229R-99.

c) Engineered fill is expected to be compacted to 95 percent of its maximum dry density, with a unit weight of 110 pcf.

d) Expected range of the average shear wave velocity in the Engineered fill is 500 fps to 1000 fps.

V_s = Shear Wave Velocity

psi = pound per square inch

fps = foot per second

Subsection 3.7.1.1 Changes

Subsection 3.7.1.1.1 will be modified from:

"Figure 2.5.2-296 shows the comparison of the horizontal and vertical site-specific ground motion response spectra (GMRS) to the AP1000 certified design seismic design response spectra (CSDRS). The horizontal and vertical response spectra were developed as free-field outcrop motions on the uppermost in-situ competent material as described in Subsection 2.5.2.6. Site response analyses were conducted to evaluate the effect of 1300 meters (4300 feet) of Cretaceous and Cenozoic limestone and dolomite on the generic CEUS hard rock ground motions as described in Subsection 2.5.2.5. GMRS are enveloped by CSDRS by a factor of > 2 for both the horizontal and vertical GMRS in the entire frequency range of interest.

The horizontal GMRS peak ground acceleration at 100 hertz is 0.069g and the vertical GMRS peak ground acceleration at 100 hertz is 0.051g as noted in Table 2.5.2-226. Where design requires site-specific seismic analysis, horizontal and vertical GMRS scaled to 0.1g and 0.074g respectively at 100 Hz shall be used.

For the purposes of shutdown criteria, the lower of the GMRS spectra scaled to 0.1g or one third of the spectra shown in DCD Figure 3.7-1 shall be used."

To read:

"Figure 2.5.2-296 shows the comparison of the horizontal and vertical site-specific ground motion response spectra (GMRS) to the AP1000 certified design seismic design response spectra (CSDRS). The GMRS was developed as the Truncated Soil Column Surface Response (TSCSR) on the uppermost in-situ competent material (elevation 11 m (36 ft.) NAVD88) as described in Subsection 2.5.2.6.

Plant finished grade will be established at elevation 15.5 m (51 ft.) NAVD88 by placing engineered fill above in-situ material. Performance based surface horizontal and vertical response spectra (PBSRS) at the finished grade elevation were developed using the same methodology and in-situ soil properties used for developing the GMRS described in Subsection 2.5.2.6. Engineered fill properties presented in Table 2.5.4.5-201 were used from elevation 11 m (36 ft.) NAVD88 to elevation 15.5 m (51 ft.) NAVD88 in the response analysis. The vertical and the horizontal PBSRS were scaled by a factor that is required for the horizontal free-field soil column outcrop response spectra (SCOR) at the AP1000 foundation elevation 3.4 m (11 ft.) NAVD88 to meet the 0.1g zero period acceleration (ZPA) requirement of 10 CFR Part 50 Appendix S. The scaled horizontal and vertical SCOR FIRS at the AP1000 foundation elevation 3.4 m (11 ft.) NAVD88 are shown in RAI 03.07.01-01 Figure 19. RAI 03.07.01-01 Table 1 presents the digitized scaled horizontal and vertical PBSRS and RAI 03.07.01-01 Figure 1 presents the comparison of the AP1000 CSDRS with the scaled PBSRS for horizontal and vertical ground motions. The CSDRS envelops the PBSRS for both the horizontal and the vertical ground motions by a significant margin.

In addition to the PBSRS, finished grade Soil Structure Interaction (SSI) analysis input surface spectra were developed using Subsection 5.2.1 of the Interim Staff Guidance DC/COL-ISG-017 as described in Subsection 2.5.2.6. The finished grade surface response spectra from the three soil columns (best estimate, lower bound, and the upper bound properties) were developed using SCOR FIRS developed for elevation -7.3 m (-24 ft.) NAVD88, the base of planned excavation beneath the nuclear island. This FIRS was scaled to ensure that the computed SCOR at the AP1000 foundation elevation 3.4 m (11 ft.) NAVD88 meets the 0.1g minimum ZPA requirement of 10 CFR Part 50 Appendix S. Figure 3.7.1-201 shows the scaled SCOR FIRS for elevation -7.3 m (-24 ft.) NAVD88. The three soil property profiles were developed based on the variation in the randomized soil profiles used for developing PBSRS and complying with SRP

3.7.2.II.4 guidance on soil property variation for SSI analysis. The shear wave velocity profiles for the upper bound (UB), best estimate (BE) and lower bound (LB) soil profiles are shown in RAI 03.07.01-01 Figure 2. The soil column profile and soil properties are presented in RAI 03.07.01-01 Tables 2, 3, and 4 for BE, LB, and UB cases respectively. Both horizontal and vertical SSI input response spectra were developed. The SSI input spectra from the UB, BE, and LB soil columns (RAI 03.07.01-01 Figures 3, 4 and 5) along with the corresponding acceleration time histories and corresponding UB, BE, and LB soil column profiles (RAI 03.07.01-01 Tables 2, 3, and 4) would be used for Nuclear Island SSI analysis, if required. The envelope of the SSI input spectra from the UB, LB, and BE envelops the PBSRS as required by DC/COL-ISG-017. RAI 03.07.01-01 Figures 3 and 4 present the comparison of the AP1000 CSDRS with the SSI input response spectra from the UB, BE, and LB soil columns for the horizontal ground motions for the North-South (H1) and the East-West (H2) directions. The CSDRS envelops the SSI input response spectra from the three soil columns. Thus, site specific SSI analysis for horizontal ground motions is not required.

For the vertical ground motions, RAI 03.07.01-01 Figure 5 presents the comparison of the AP1000 CSDRS with the scaled PBSRS and the SSI input response spectra from the three soil columns. The CSDRS envelops the scaled vertical PBSRS by a similarly large margin as the horizontal. However, it does not envelop the finished grade surface SSI input response spectra from the three soil columns in the high frequency range (greater than approximately 30 Hz). For the vertical direction, the response at the top of the free field soil columns overestimates amplification that will be experienced by the AP1000. This is due to the fact that the AP1000 mat for LNP is supported vertically on the 35' RCC mat that rests on rock. Amplification of the vertical motion to the AP1000 mat will be minimal because of the high shear wave (3500 ft/sec) velocity through the RCC mat. As shown in Figure 3.7.1-201 the vertical CSDRS envelops the scaled vertical FIRS at the base of the excavation by a large margin. Based on this large margin and the minimal amplification expected through the RCC mat, CSDRS-based vertical in-structure spectra is judged to envelop the corresponding site-specific FIRS-based in-structure spectra.

Section 3.7.1.1.2 will be modified from:

"The nuclear island is supported on 10.7 meters (35 feet) of roller compacted concrete over rock formations at the site as described in Subsection 2.5.4.5. The seismic Category II Annex Building and other adjacent non-seismic structures are supported on drilled shafts. The upper most in-situ competent rock occurs approximately 10.7 meters (35 feet) below the nuclear island foundation elevation. Foundation input response spectra (FIRS) were developed for the nuclear island at the top of the competent rock per Subsection 2.5.2.5. Figure 3.7-201 shows a comparison of the horizontal and vertical nuclear island FIRS to the CSDRS. The FIRS is enveloped by CSDRS by a factor of > 3 for both the horizontal and vertical FIRS in the entire frequency range of interest. These margins are large enough to accommodate any variation in Soil Structure Interaction (SSI) effects due to adjacent drilled shaft supported structures, when compared to the generic SSI analyses documented in the DCD Subsections 3.7.1.4 and 3.7.2.8.1."

To read:

"The nuclear island is supported on 10.7 meters (35 feet) of roller compacted concrete over rock formations at the site as described in Subsection 2.5.4.5. The seismic Category II Annex Building and other adjacent non-seismic structures are supported on drilled shafts. Foundation input response spectra (FIRS) were developed for the nuclear island at the base of planned excavation Subsection 2.5.2.5. Figure 3.7.1-201 shows a comparison of the horizontal and

vertical nuclear island FIRS at elevation -7.3 m (-24 ft.) NAVD88 to the CSDRS. The scaled horizontal and vertical FIRS at the AP1000 foundation Elevation 3.4 m (11 ft.) NAVD88 are shown in RAI 03.07.01-01 Figure 19.

The top of the basemat for the Annex Building, Radwaste building, and the Turbine Building (except for the condenser pit area) is at finished grade elevation 15.5 m (51 ft.) NAVD88. The PBSRS described in Subsection 3.7.1.1.1 (RAI 03.07.01-01 Figure 19 and RAI 03.07.01-01 Table 1) are used to compute the maximum relative displacements of the Annex Building, Turbine Building, and the Radwaste Building drilled shaft foundation with respect to the Nuclear Island to evaluate site-specific aspect of the seismic interaction of these buildings with the Nuclear Island."

Figure changes and additions:

FSAR Figure Revisions:

FSAR Figure 2.5.2-281 will be replaced by revised figure listed under **Attachments/Enclosures to Response to NRC** below.

FSAR Figure 2.5.2-282 will be replaced by revised figure listed under **Attachments/Enclosures to Response to NRC** below.

FSAR Figure 2.5.2-283 will be replaced with three new figures listed under **Attachments/Enclosures to Response to NRC** below.

FSAR Figure 2.5.2-284 will be replaced with three new figures listed under **Attachments/Enclosures to Response to NRC** below.

FSAR Figure 3.7.1-201 will be replaced by revised figure listed under **Attachments/Enclosures to Response to NRC** below.

FSAR Figure Additions:

RAI 03.07.01-01 Figures 1, 2, and 6 through 18 will be added to Section 2.5.2

RAI 03.07.01-01 Figures 3 through 5 and 19 will be added to Section 3.7.1

References (References 01 through 03 will be added to a future revision of the FSAR)

Reference RAI 03.07.01-01 01

Darendeli, M.B, Development of a New Family of Normalized Modulus Reduction and Material Damping Curves, Ph.D Thesis, University of Texas, Austin, 2001.

Reference RAI 03.07.01-01 02

Menq, F.Y., Dynamic Properties of Sandy and Gravelly Soils, Ph.D Thesis, University of Texas, Austin, 2003.

Reference RAI 03.07.01-01 03

Power, M., B. Chiou, N. Abrahamson, Y. Bozorgnia, T. Shantz, and C. Roblee, An Overview of the NGA Project, Earthquake Spectra, v. 24, p. 3-21, 2008.

Attachments/Enclosures:

Attachment 03.07.01-01A Figures

- Revised Figure 2.5.2-281
- Revised Figure 2.5.2-282
- Revised Figures 2.5.2-283a, -283b and -283c (three sheets to replace original)
- Revised Figures 2.5.2-284a, -284b and -284c (three sheets to replace original)
- Revised Figure 3.7.1-201
- RAI 03.07.01-01 Figure 1
- RAI 03.07.01-01 Figure 2
- RAI 03.07.01-01 Figure 3
- RAI 03.07.01-01 Figure 4
- RAI 03.07.01-01 Figure 5
- RAI 03.07.01-01 Figure 6
- RAI 03.07.01-01 Figure 7
- RAI 03.07.01-01 Figure 8
- RAI 03.07.01-01 Figure 9
- RAI 03.07.01-01 Figure 10
- RAI 03.07.01-01 Figure 11
- RAI 03.07.01-01 Figure 12
- RAI 03.07.01-01 Figure 13
- RAI 03.07.01-01 Figure 14
- RAI 03.07.01-01 Figure 15
- RAI 03.07.01-01 Figure 16
- RAI 03.07.01-01 Figure 17
- RAI 03.07.01-01 Figure 18
- RAI 03.07.01-01 Figure 19
- RAI 03.07.01-01 Figure 20
- RAI 03.07.01-01 Figure 21
- RAI 03.07.01-01 Figure 22

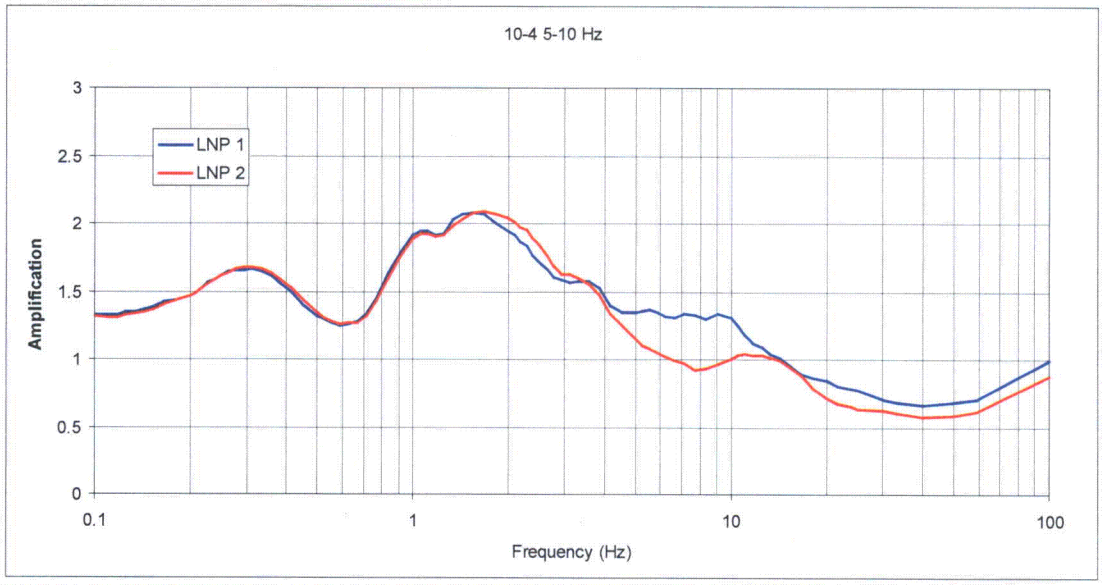
Attachment 03.07.01-01B New 2.5.2 Tables

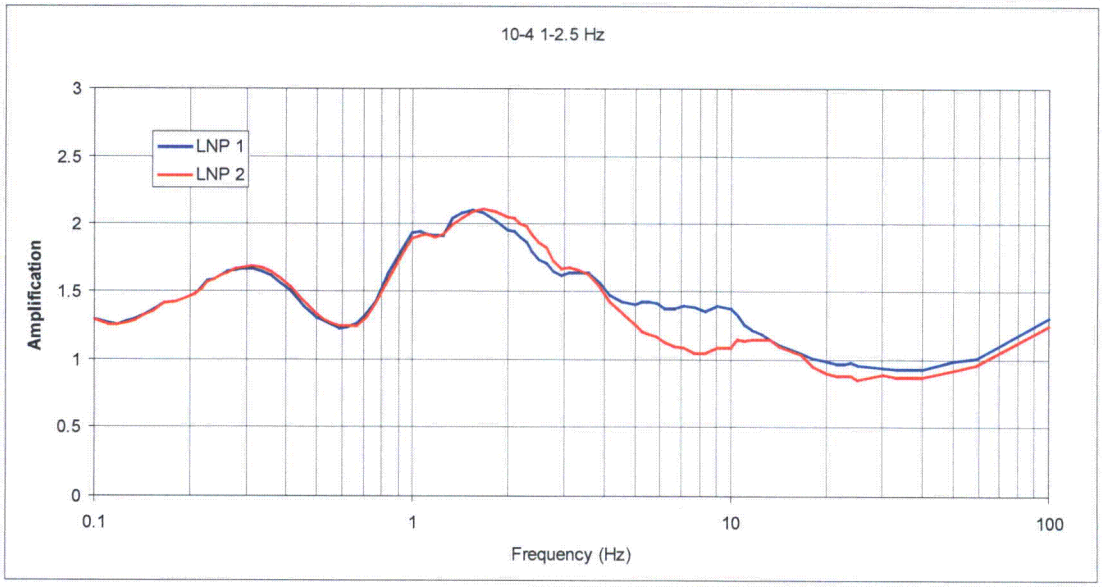
- RAI 03.07.01-01 Table 1
- RAI 03.07.01-01 Table 2
- RAI 03.07.01-01 Table 3
- RAI 03.07.01-01 Table 4

Attachment A to Letter NPD-NRC-2009-222

Figures

(31 pages following this cover sheet)

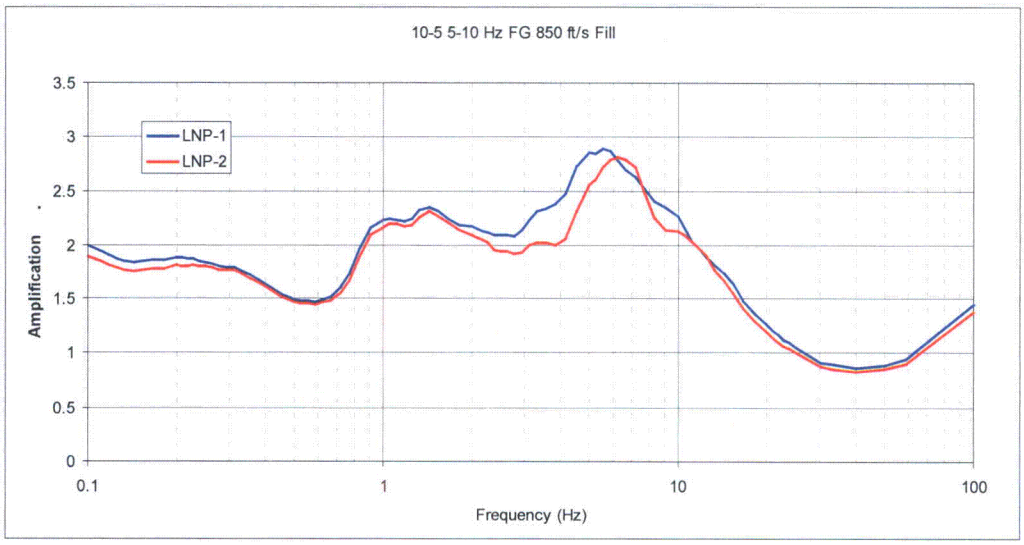


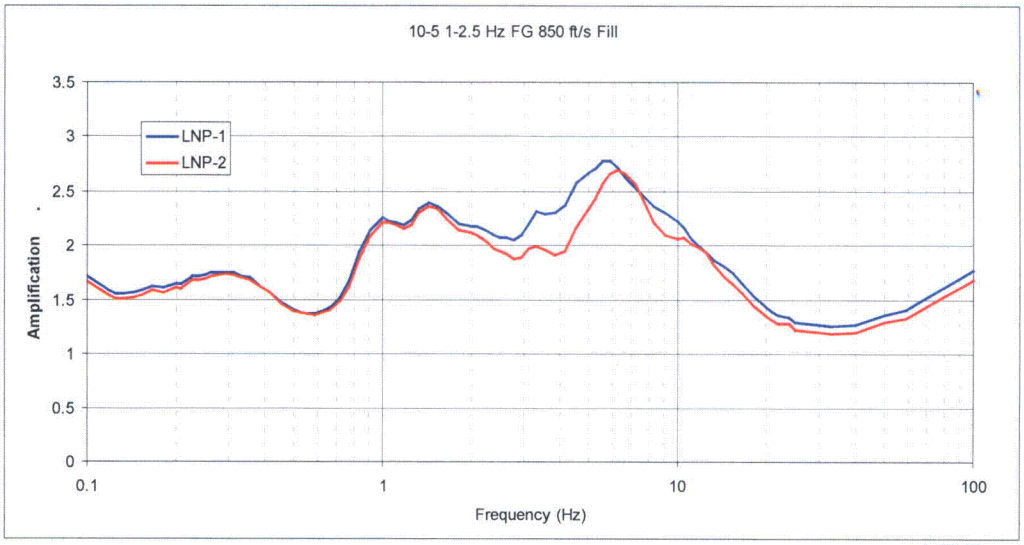


Progress Energy Florida

Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Comparison of Mean Site Amplification for the LNP 1 and LNP 2 Finished Grade Profiles for 850 ft/sec Fill Velocity and 10^{-4} Ground Motion
FIGURE 2.5.2-281 (Revised)





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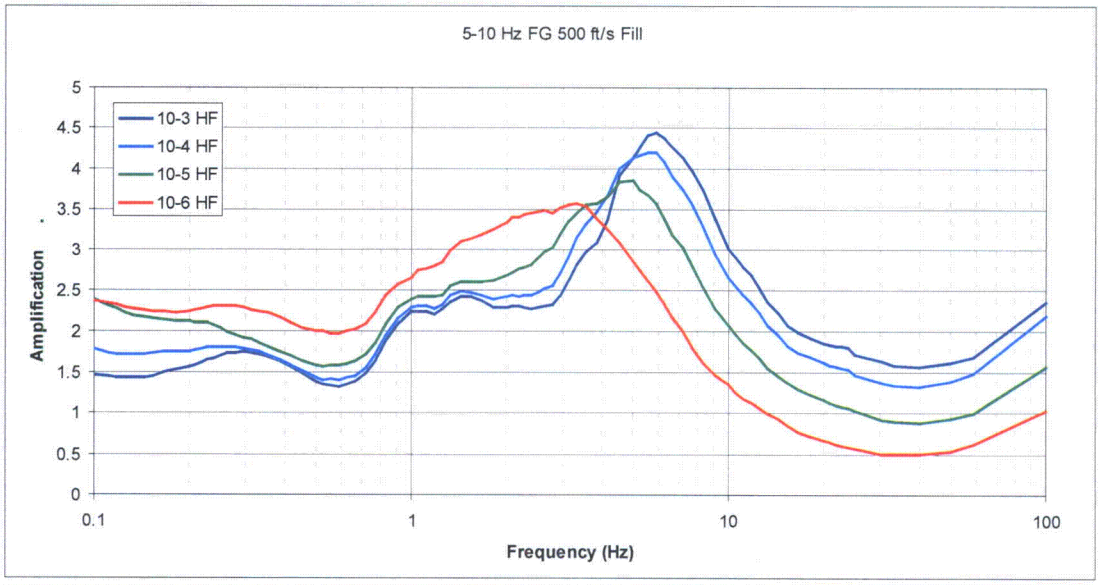
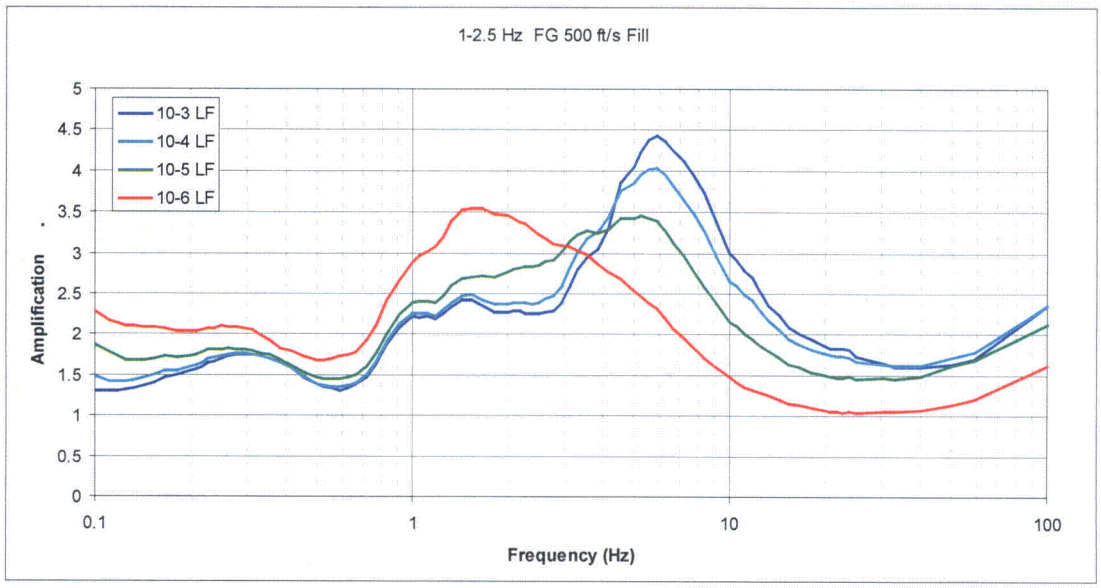
Comparison of Mean Site Amplification for the LNP-1 and LNP-2 Finished Grade Profiles, 850 ft/sec Fll Velocity and 10^{-5} Ground Motion Input
FIGURE 2.5.2-282 (Revised)





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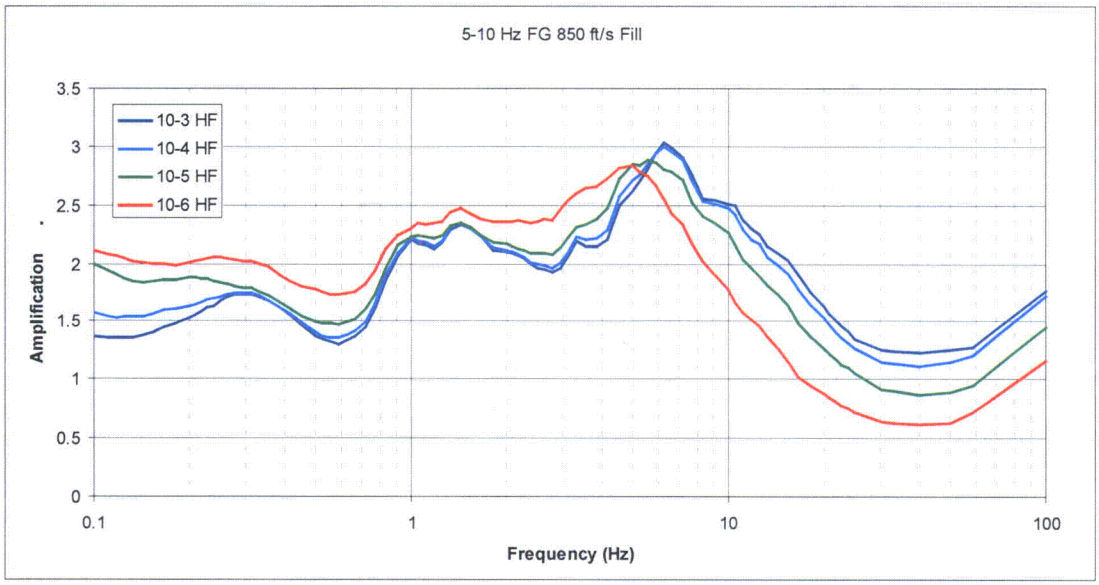
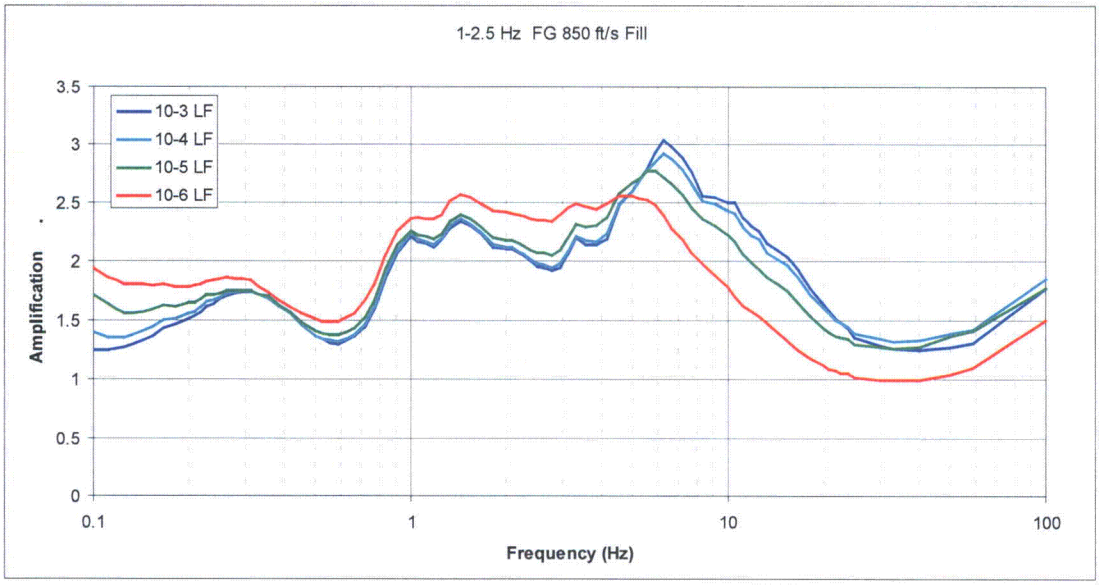
Envelop of Finished Grade Amplification Functions for the 500 ft/sec Fill Velocity

FIGURE 2.5.2-283a (Revised)





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Levy Nuclear Plant
Units 1 and 2
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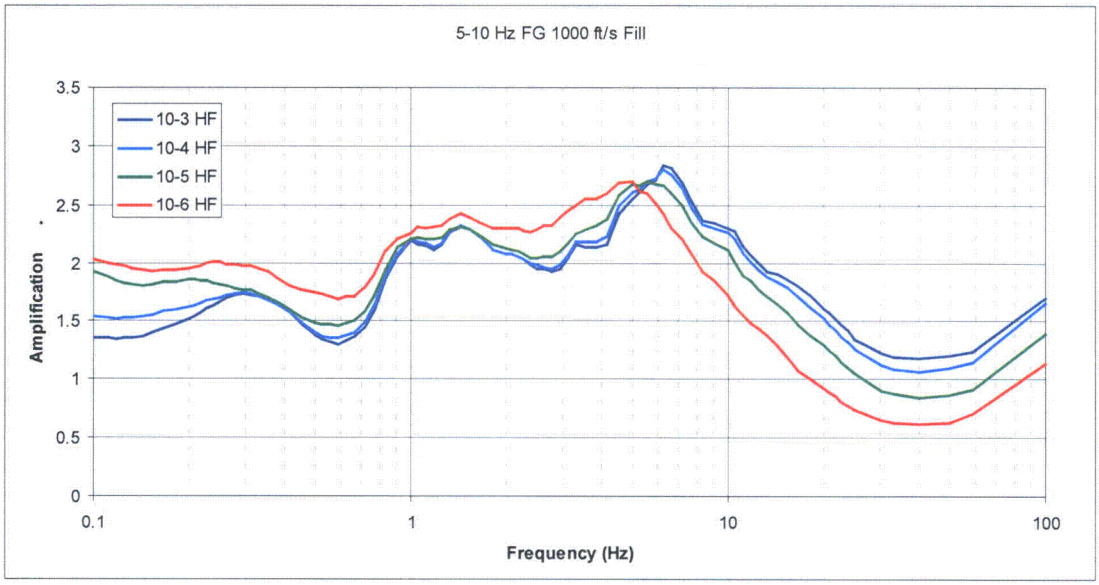
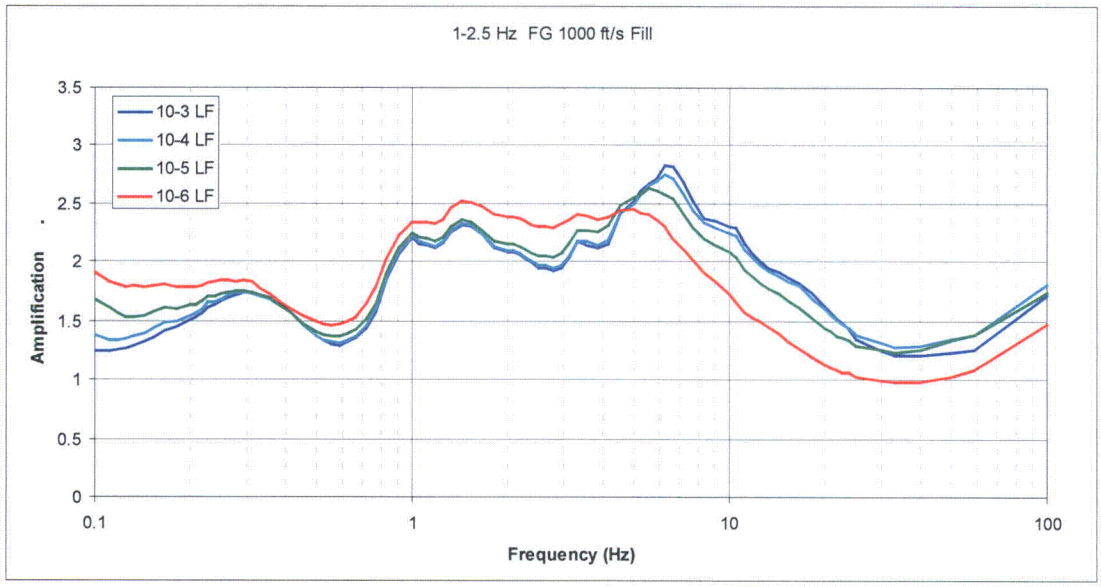
Envelop of Finished Grade Amplification Functions for the 850 ft/sec Fill Velocity

FIGURE 2.5.2-283b (Revised)





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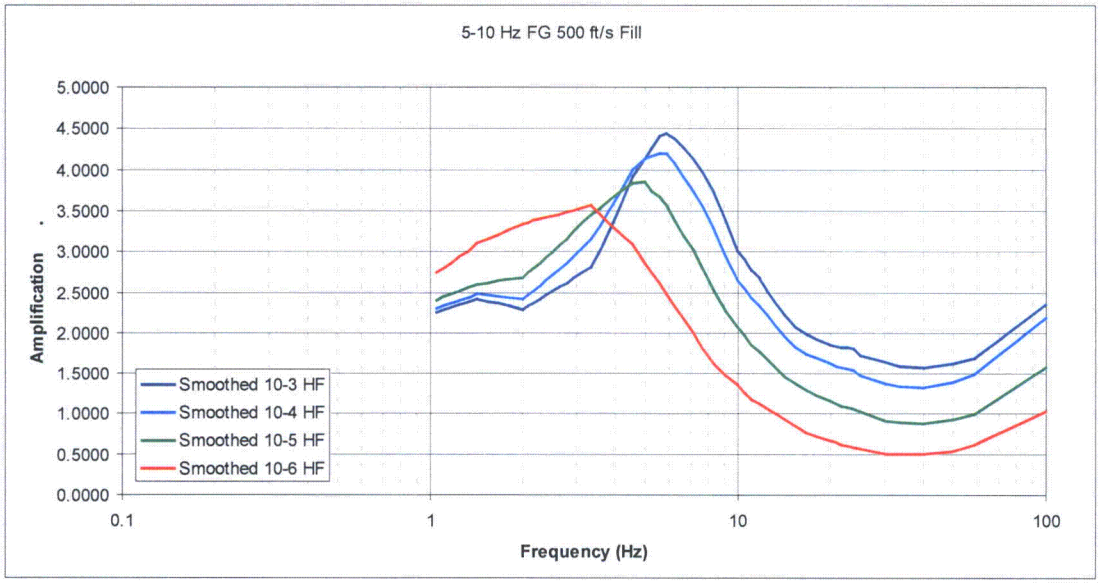
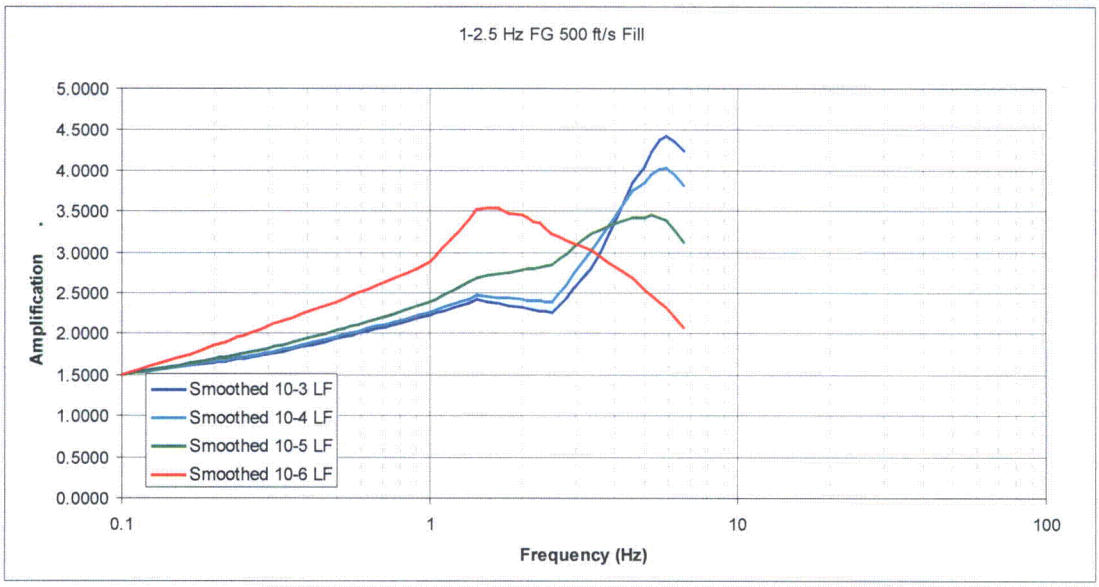
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Envelop of Finished Grade Amplification Functions for the 1000 ft/sec Fill Velocity

FIGURE 2.5.2-283c (Revised)





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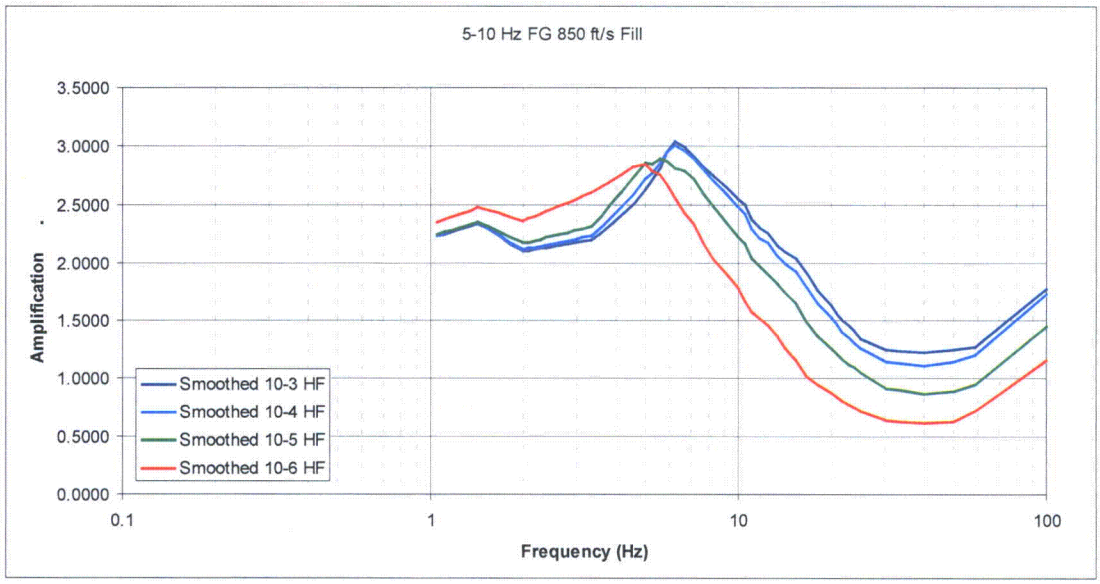
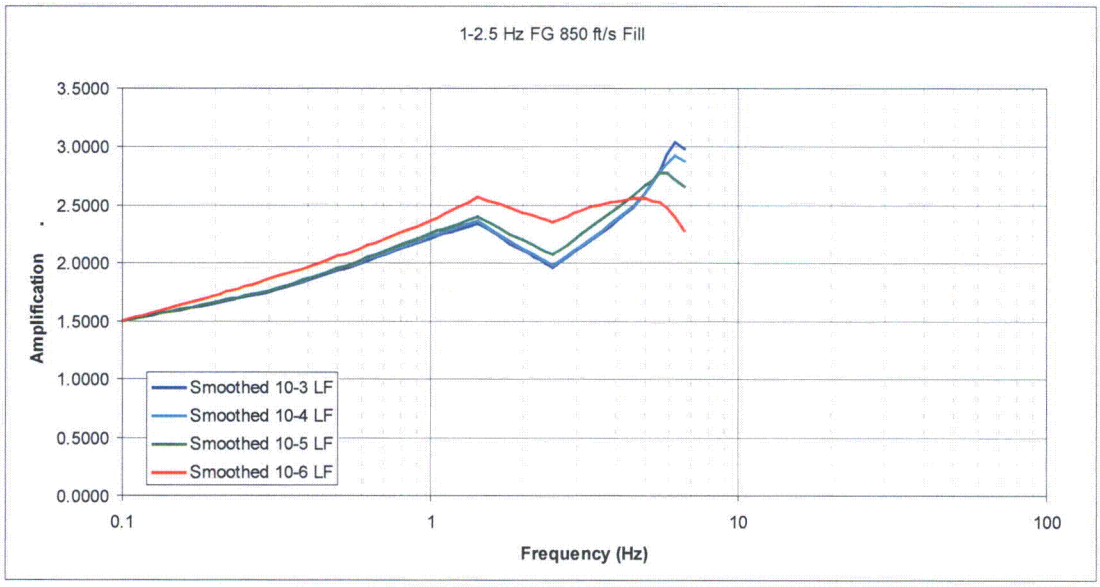
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Smoothed Envelop Finished Grade
Amplification Functions for the
500 ft/sec Fill Case
FIGURE 2.5.2-284a (Revised)





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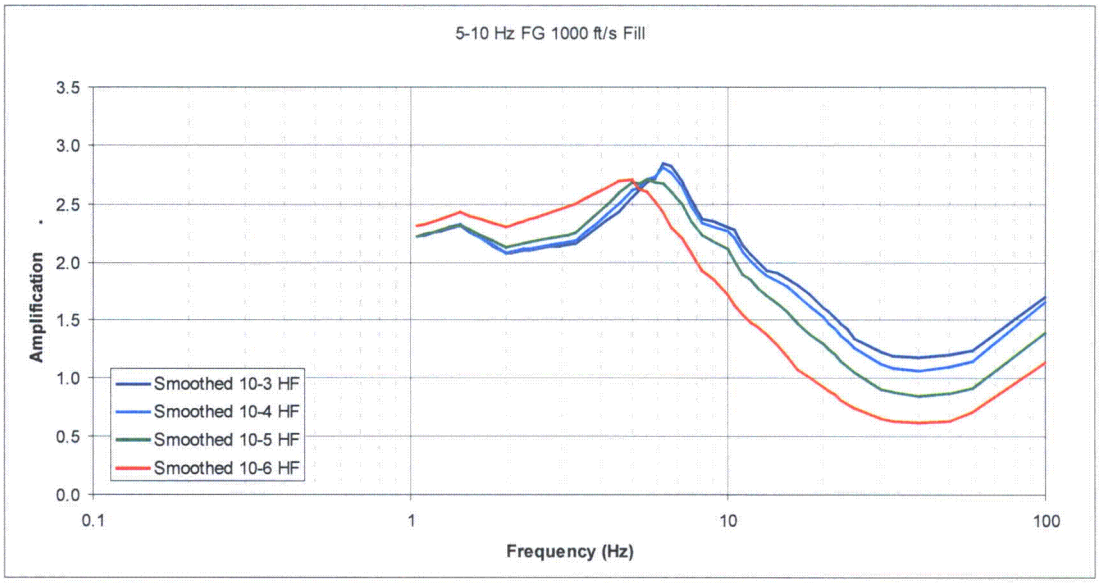
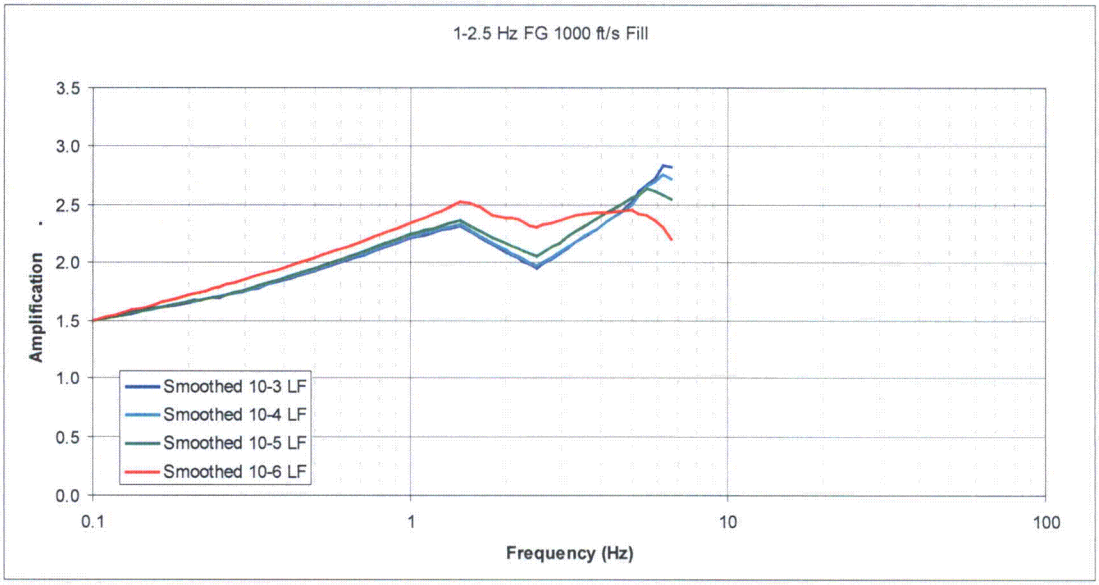
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Smoothed Envelop Finished Grade
Amplification Functions
for the 850 ft/sec Fill Case
FIGURE 2.5.2-284b (Revised)





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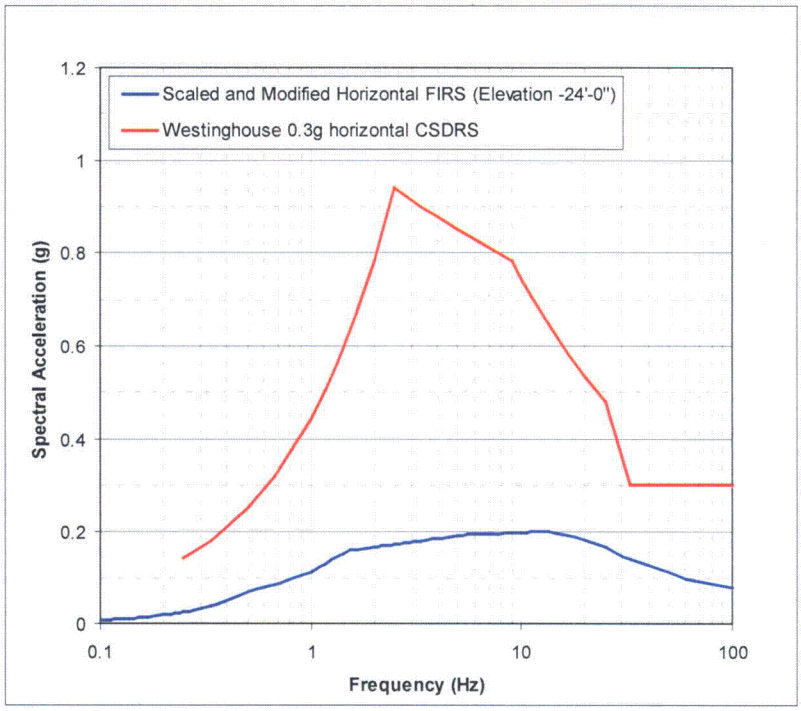
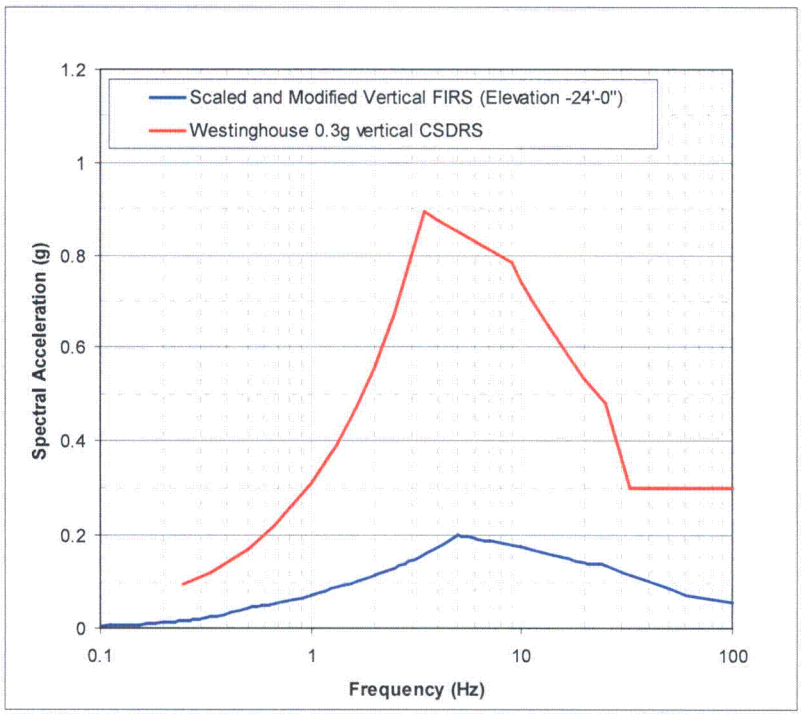
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Smoothed Envelop Finished Grade
Amplification Functions
for the 1000 ft/sec Fill Case
FIGURE 2.5.2-284c (Revised)

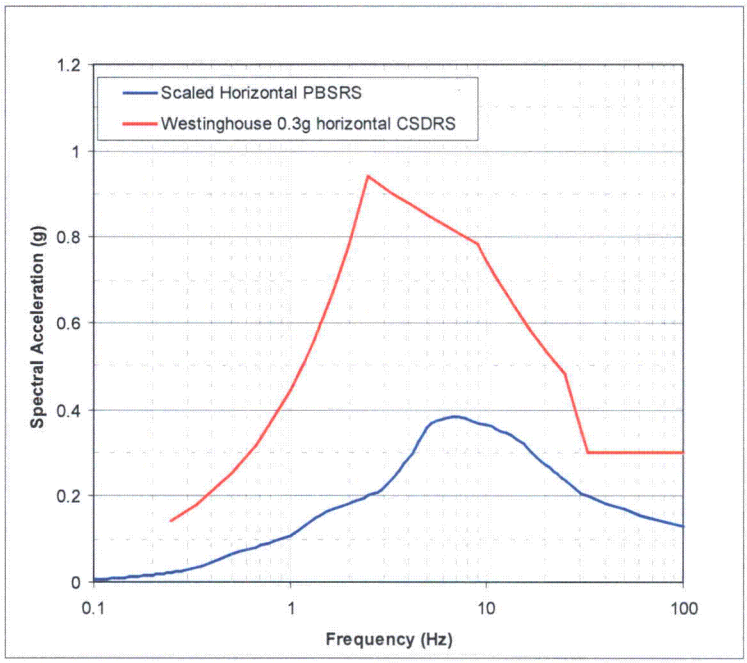


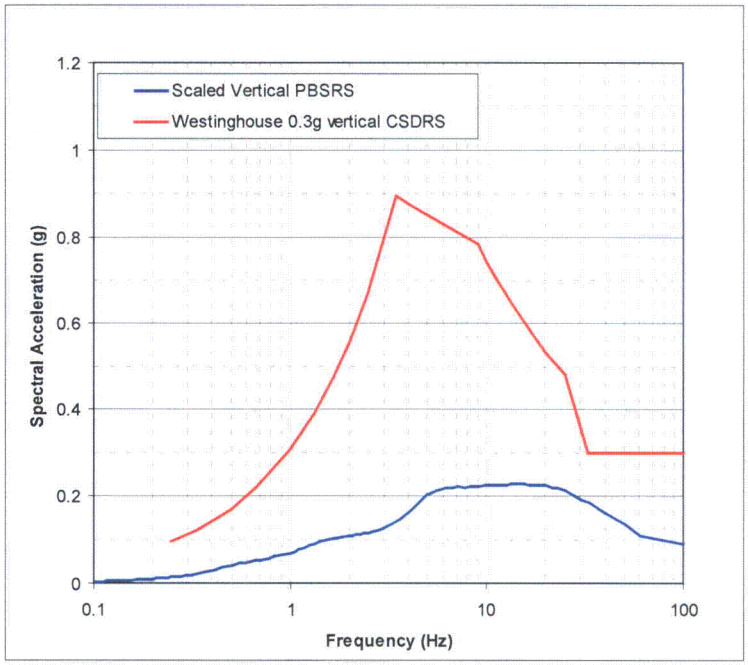


Progress Energy Florida

Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Horizontal and Vertical Scaled
SCOR FIRS for the Levy Site
Compared to the Westinghouse CSDRS
FIGURE 3.7.1-201 Rev 1





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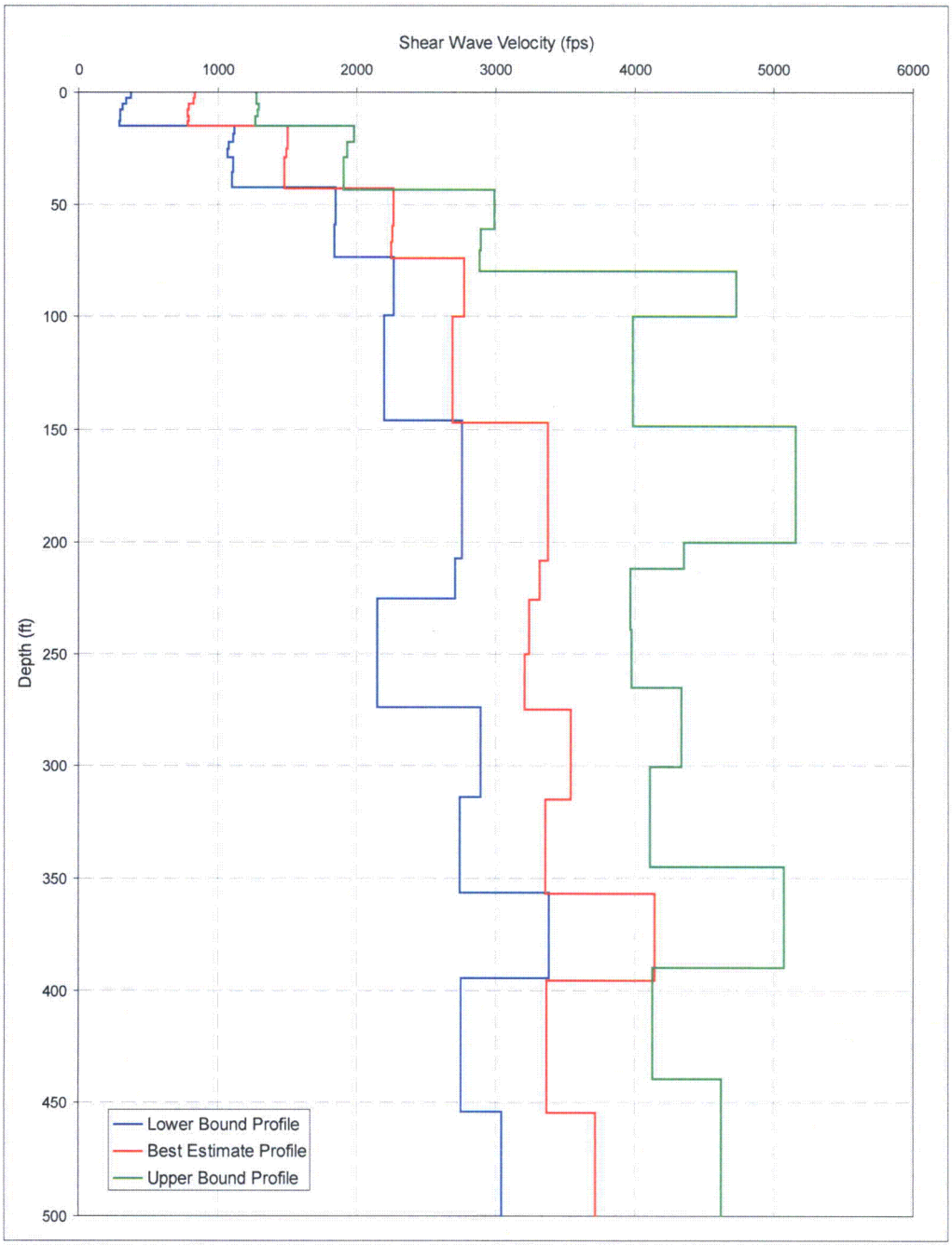
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Horizontal and Vertical Scaled PBSRS for the Levy Site Compared to the Westinghouse CSDRS
RAI 03.07.01-01 FIGURE 1



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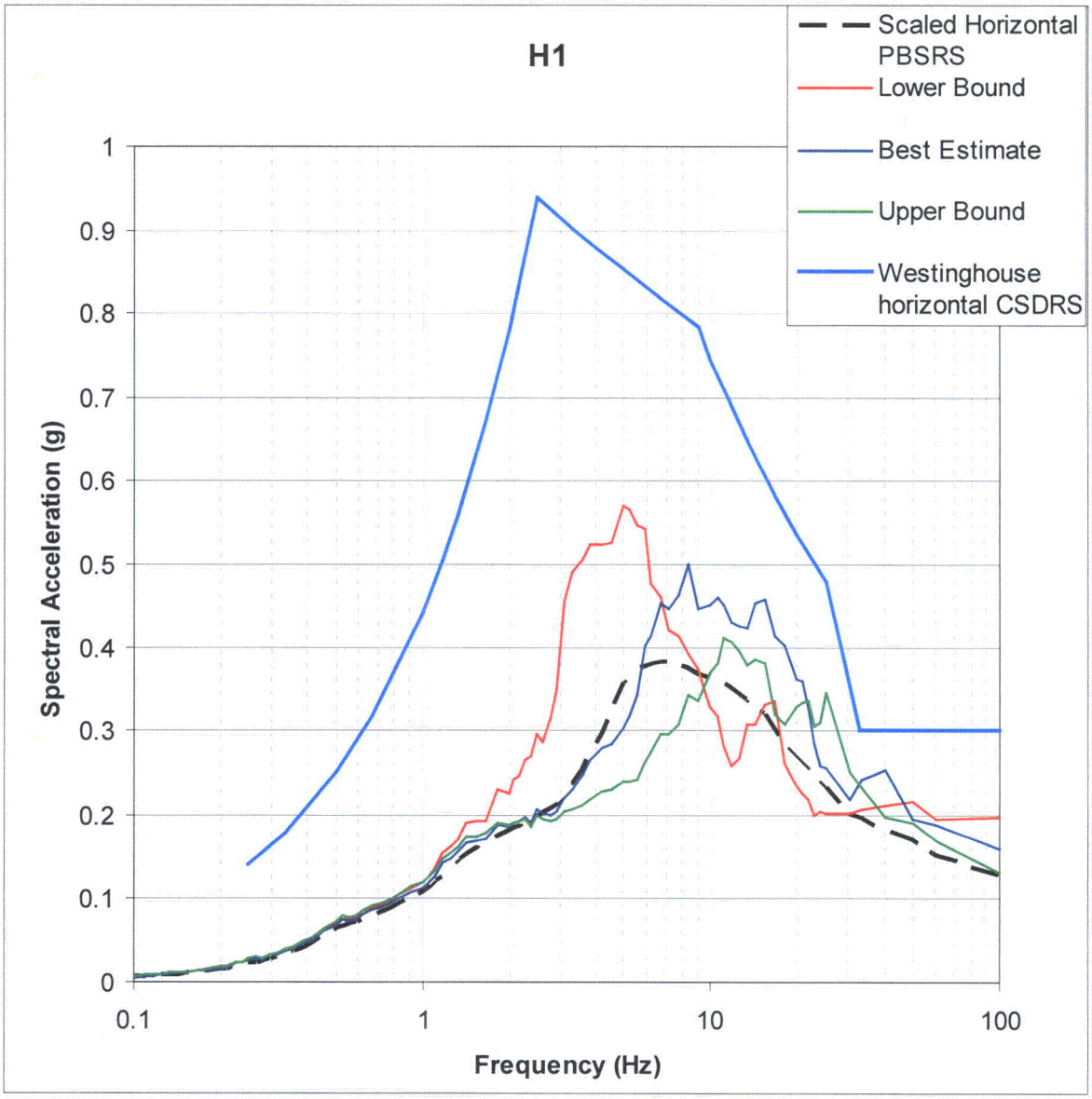
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Lower Bound, Best Estimate, and Upper Bound SSI V_S Profiles.

RAI 03.07.01-01 FIGURE 2



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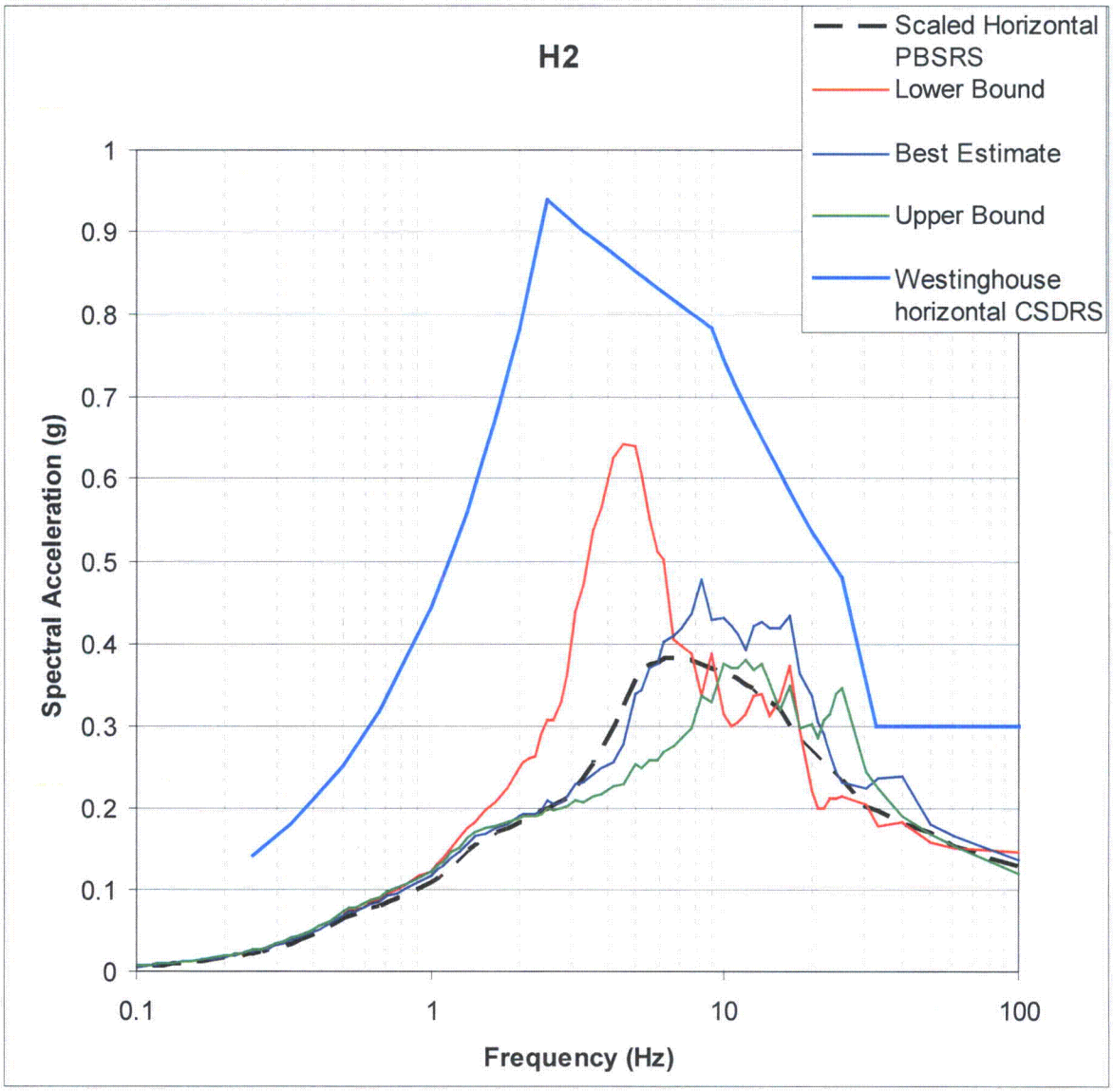
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Comparison of Spectra of Computed H1 Component Surface Motions for SSI Profiles with Scaled Horizontal PBSRS
RAI 03.07.01-01 FIGURE 3



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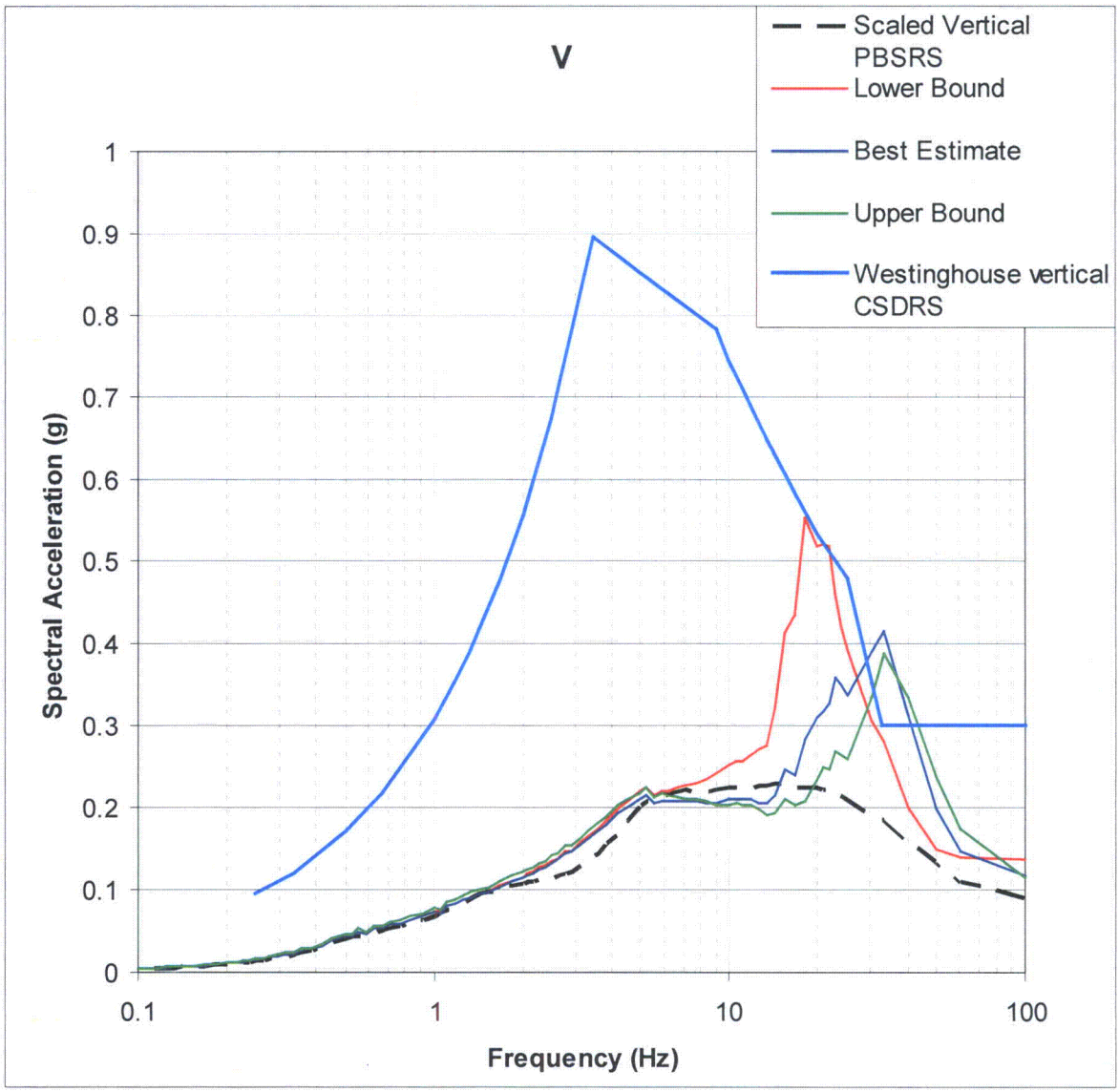
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Comparison of Spectra of Computed H2 Component Surface Motions for SSI Profiles with Scaled Horizontal PBSRS
RAI 03.07.01-01 FIGURE 4



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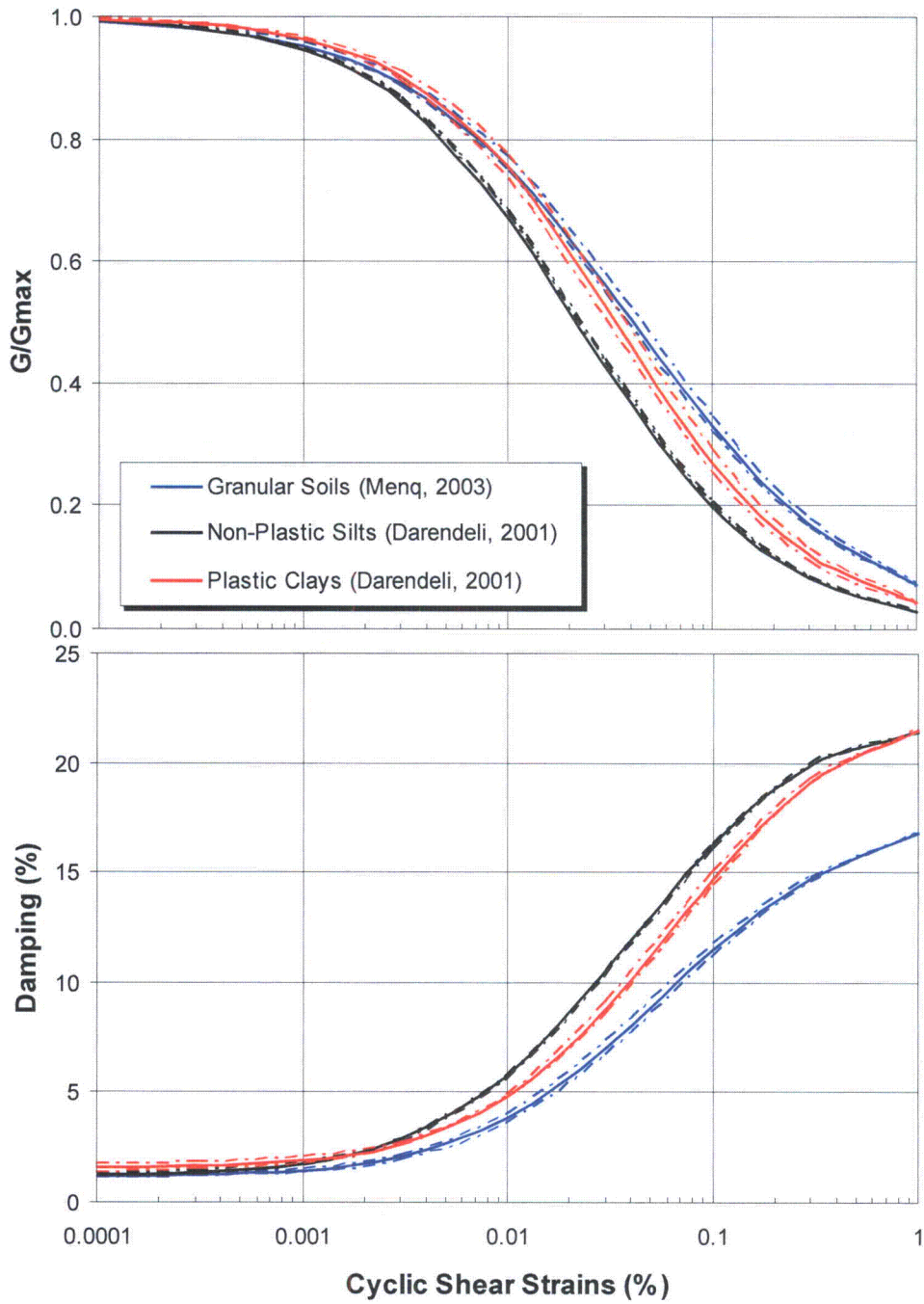
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Comparison of Spectra of Computed V Component Surface Motions for SSI Profiles with Scaled Vertical PBSRS
RAI 03.07.01-01 FIGURE 5



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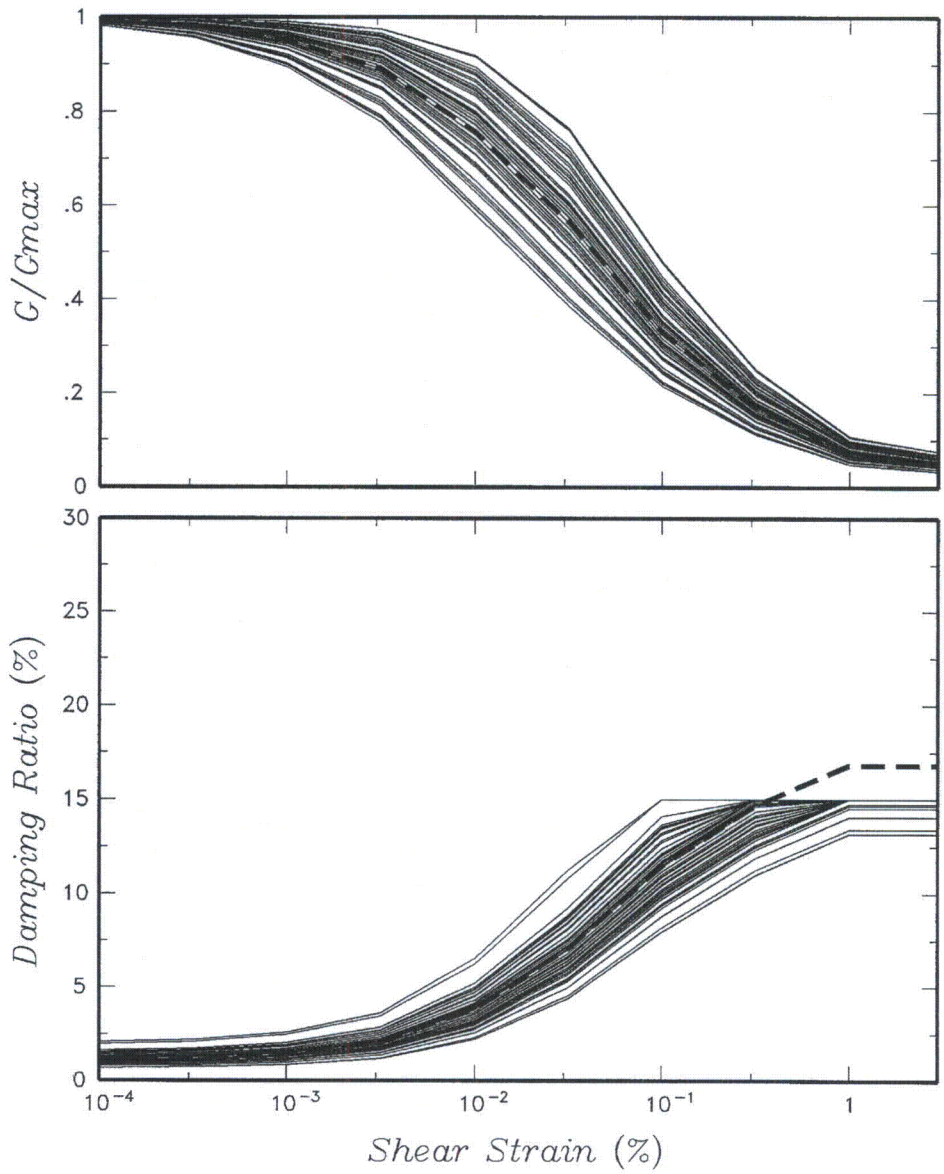
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Shear Modulus Reduction and Damping Relationships for Fill Material

RAI 03.07.01-01 FIGURE 6



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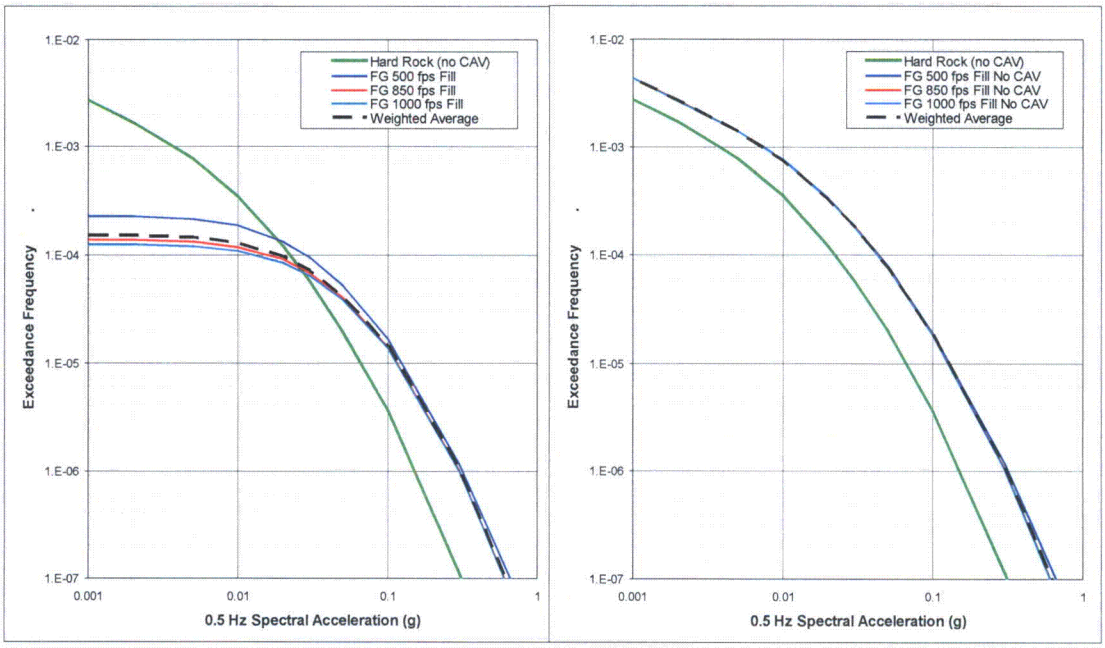
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Randomized G/Gmax
and Damping for Fill

RAI 03.07.01-01 FIGURE 7



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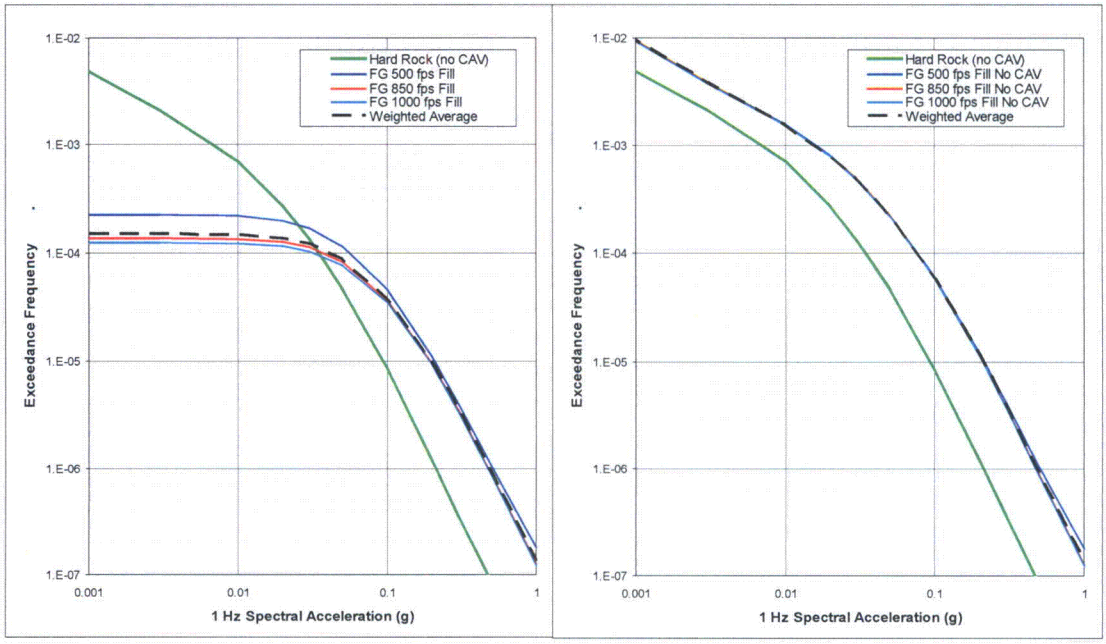
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Mean 0.5 Hz Hazard Curves Computed with and without CAV for the PBSRS Profiles

RAI 03.07.01-01 FIGURE 8



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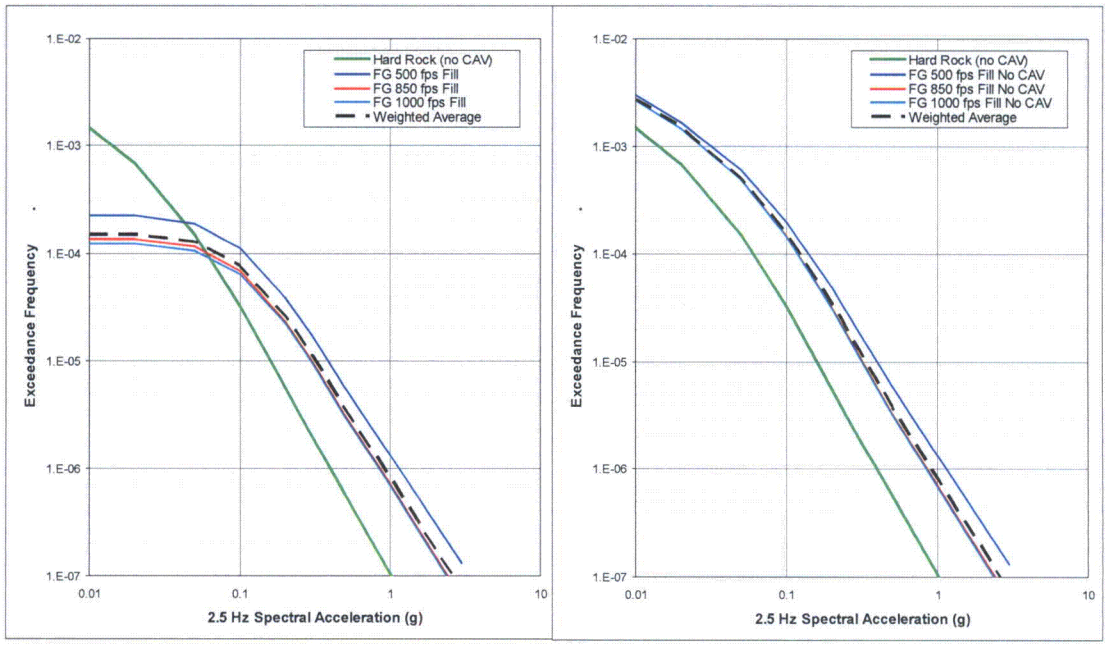
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Mean 1 Hz Hazard Curves Computed with and without CAV for the PBSRS Profiles

RAI 03.07.01-01 FIGURE 9



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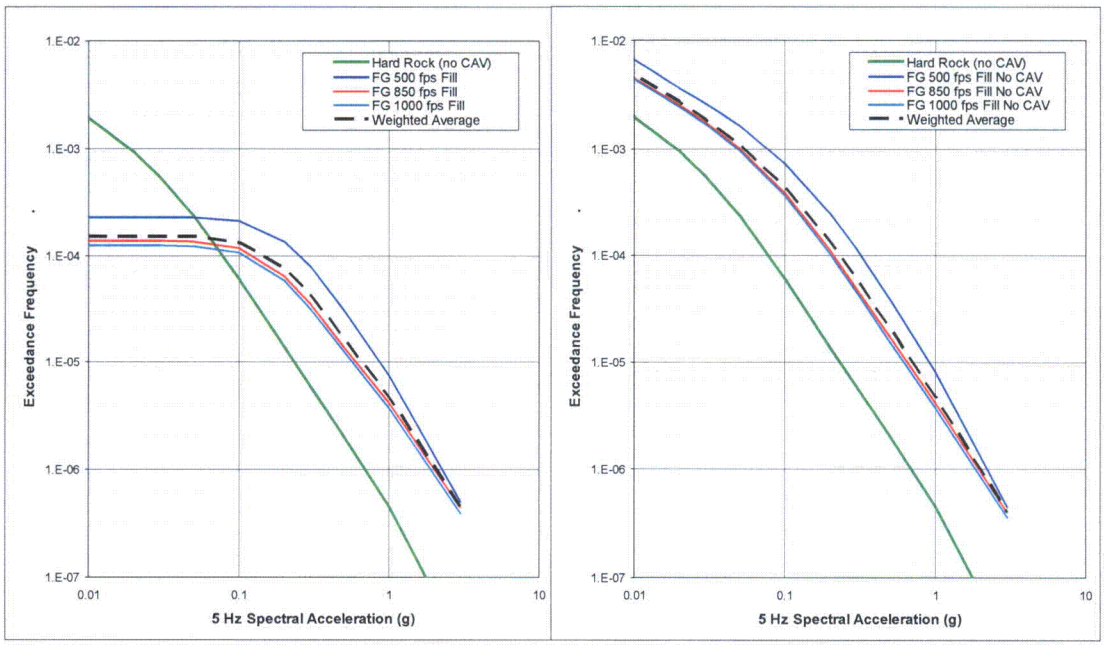
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Mean 2.5 Hz Hazard Curves Computed with and without CAV for the PBSRS Profiles

RAI 03.07.01-01 FIGURE 10



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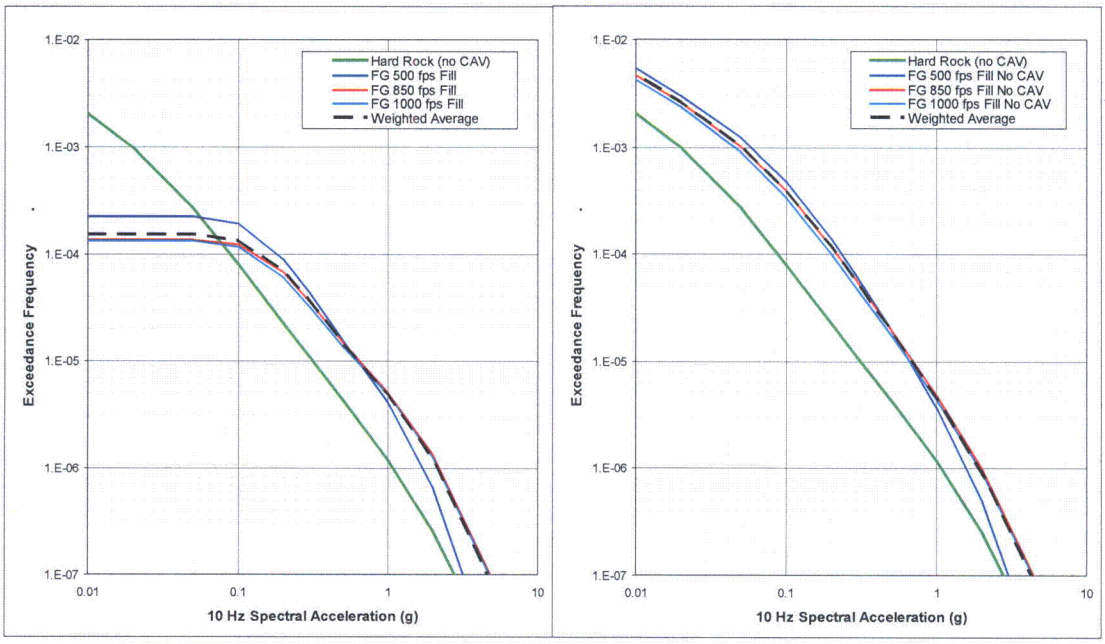
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Mean 5 Hz Hazard Curves Computed with and without CAV for the PBSRS Profiles

RAI 03.07.01-01 FIGURE 11



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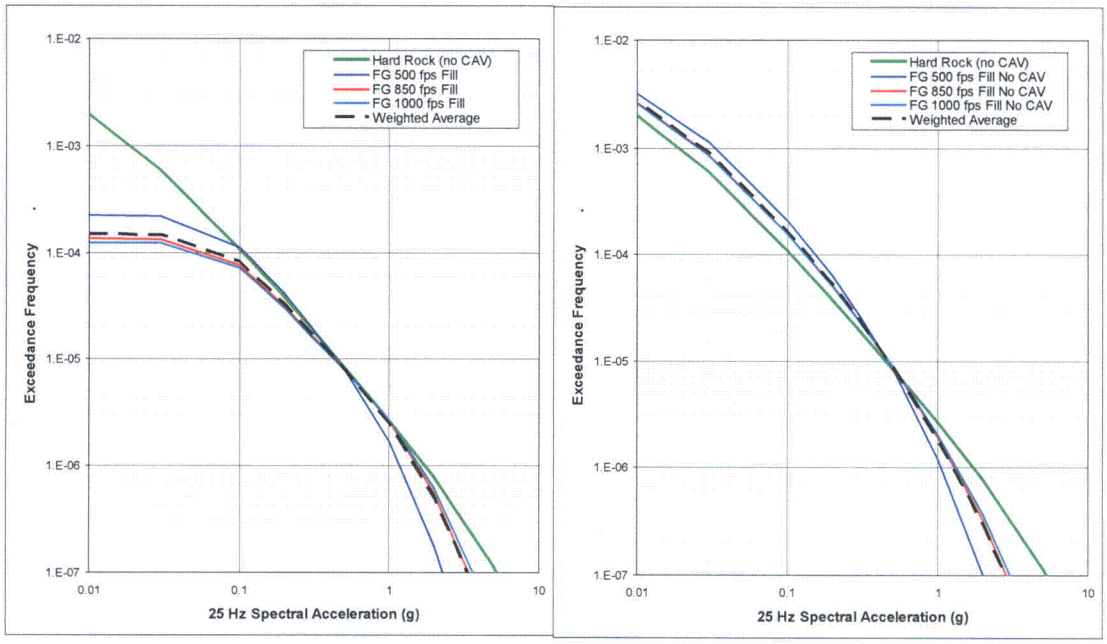
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Mean 10 Hz Hazard Curves Computed with and without CAV for the PBSRS Profiles

RAI 03.07.01-01 FIGURE 12



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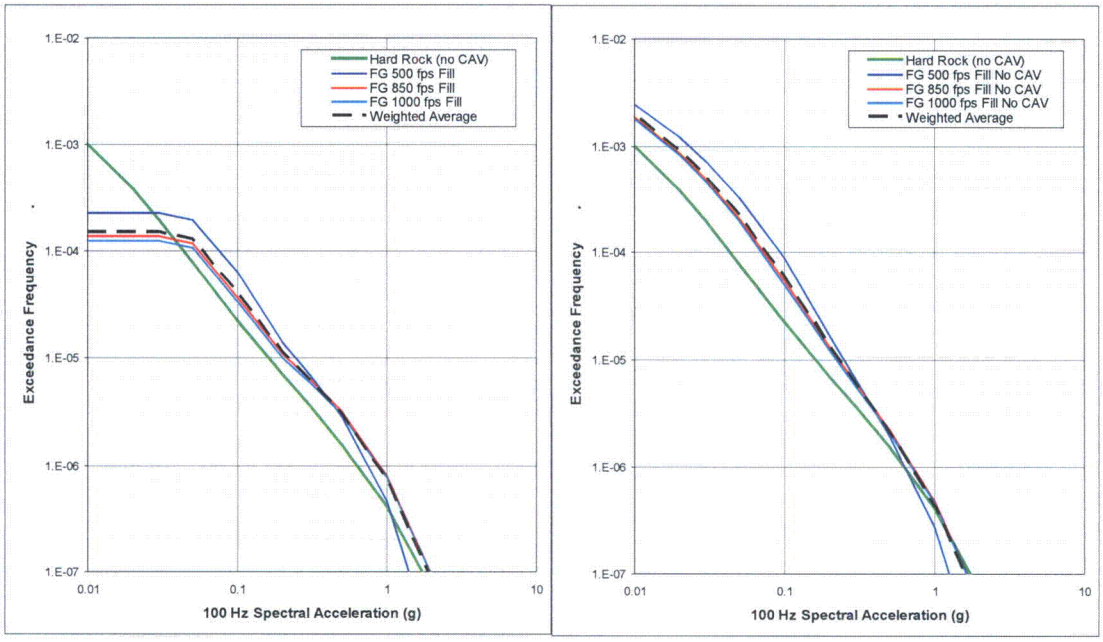
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Mean 25 Hz Hazard Curves Computed with and without CAV for the PBSRS Profiles

RAI 03.07.01-01 FIGURE 13



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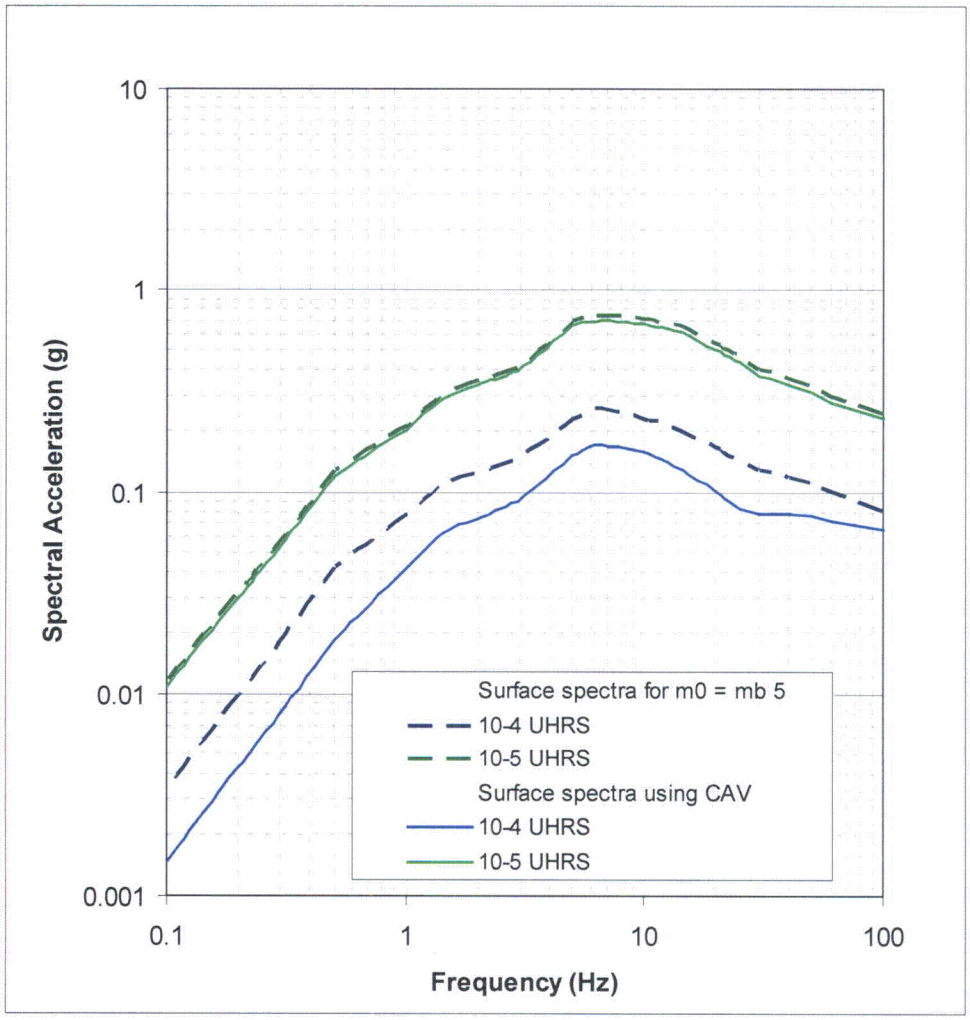
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Mean 100 Hz Hazard Curves Computed with and without CAV for the PBSRS Profiles

RAI 03.07.01-01 FIGURE 14



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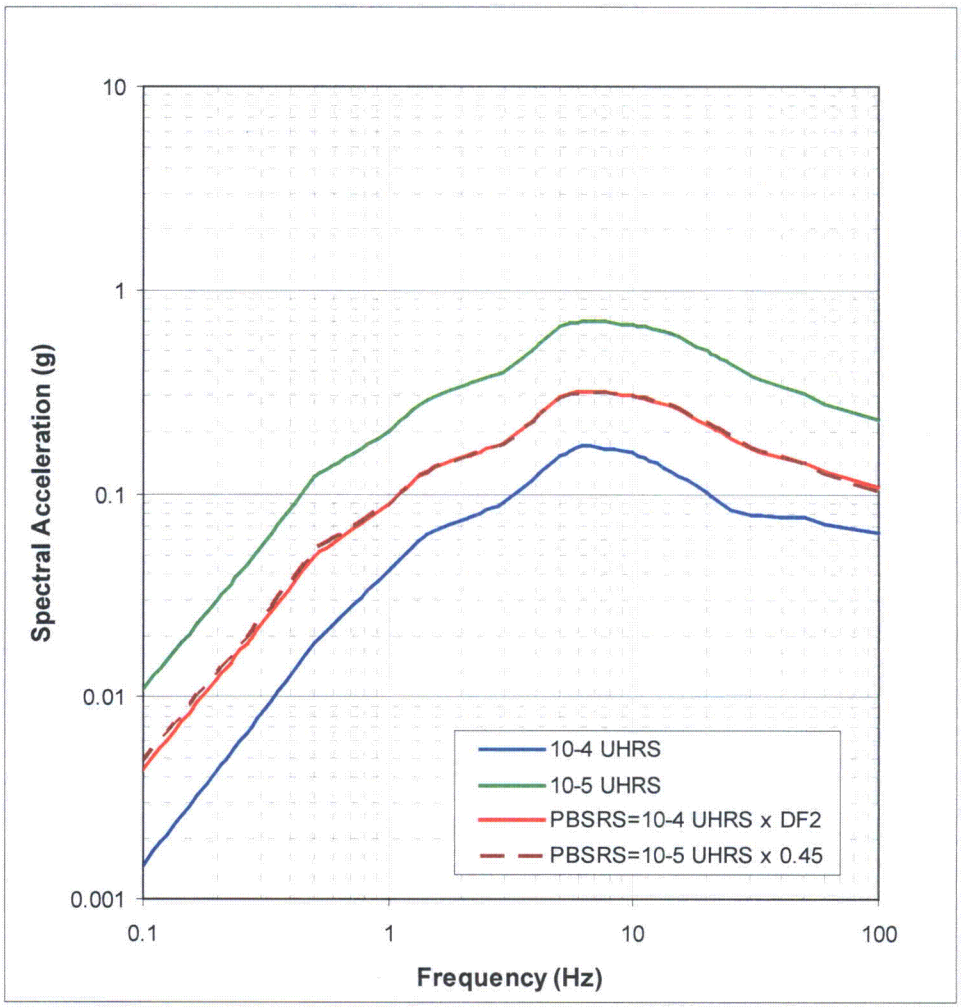
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Surface UHRS for the Levy Finished Grade PBSRS Profile Based on PSHA Inputs of Minimum Magnitude of mb 5.0 or CAV
RAI 03.07.01-01 FIGURE 15



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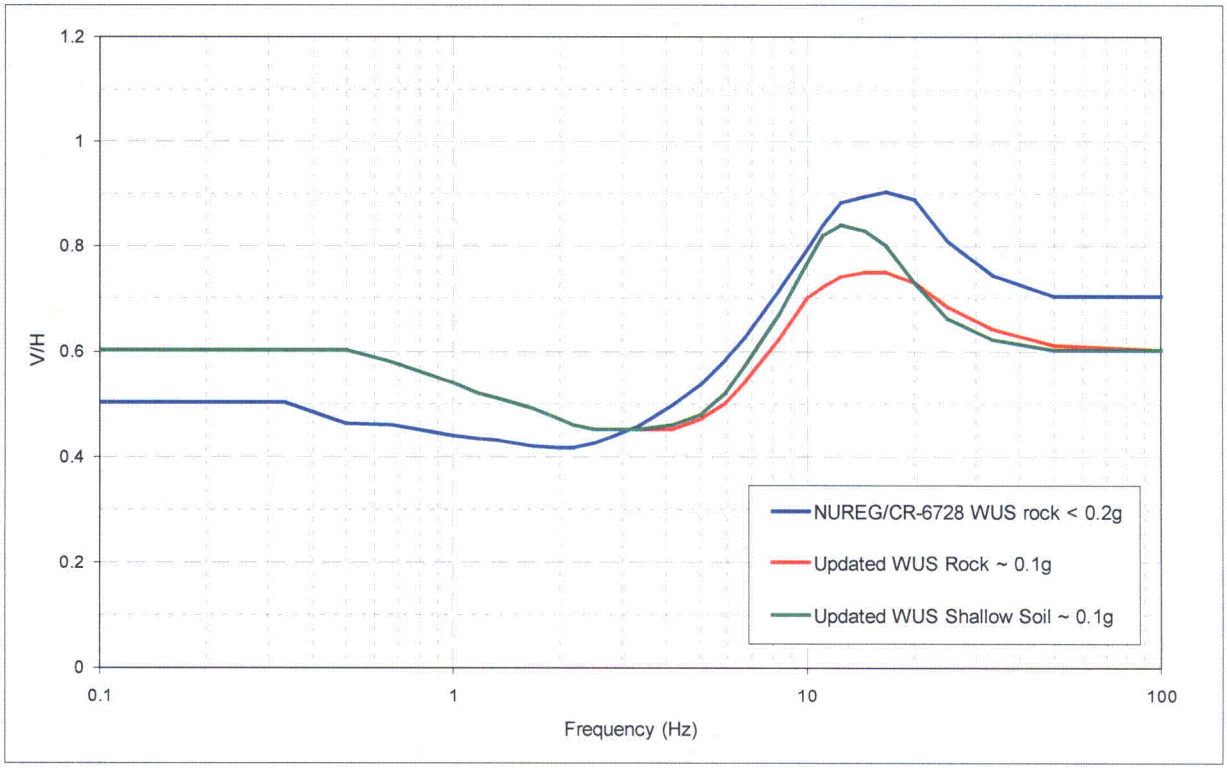
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Horizontal Finished Grade
UHRS and the PBSRS for the Levy Site

RAI 03.07.01-01 FIGURE 16



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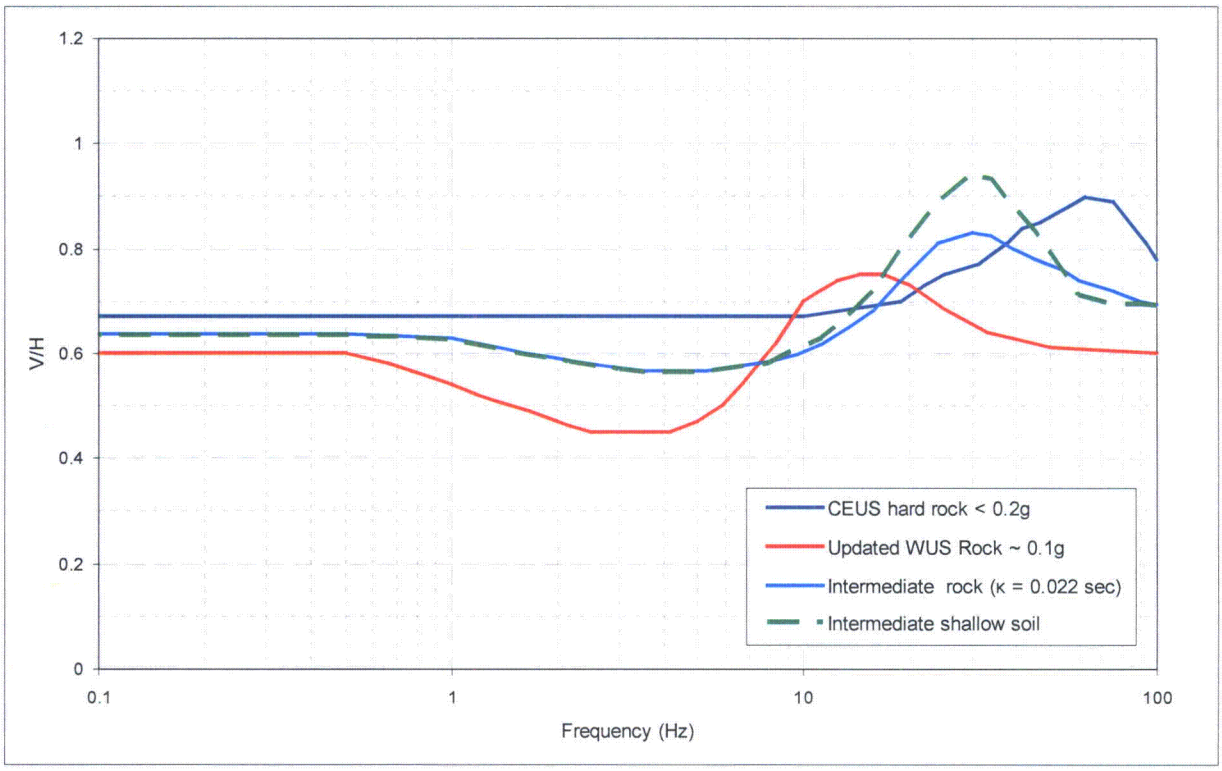
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Updated V/H Ratios for Large Distant WUS Earthquake Ground Motions Developed from the PEER NGA Data Base
RAI 03.07.01-01 FIGURE 17



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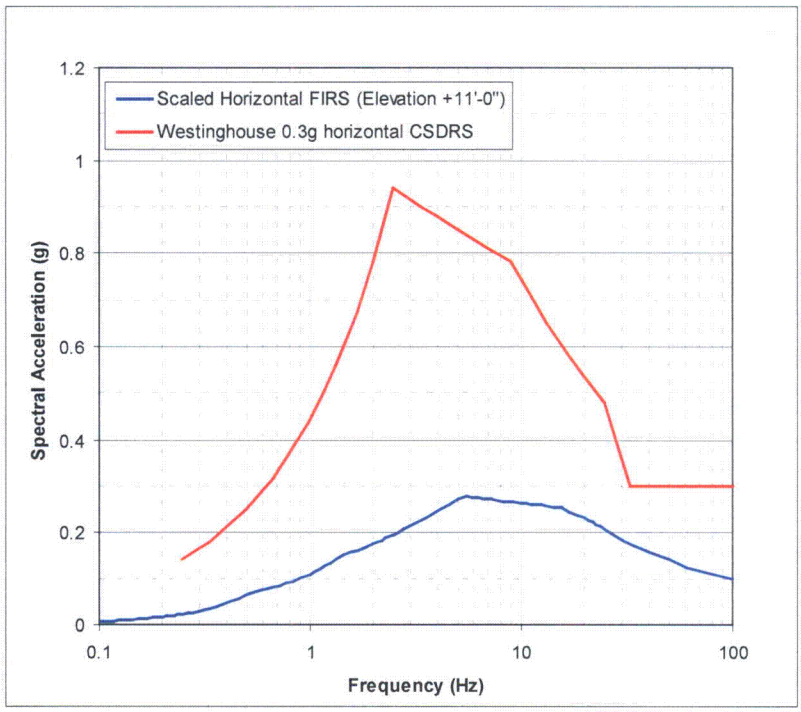
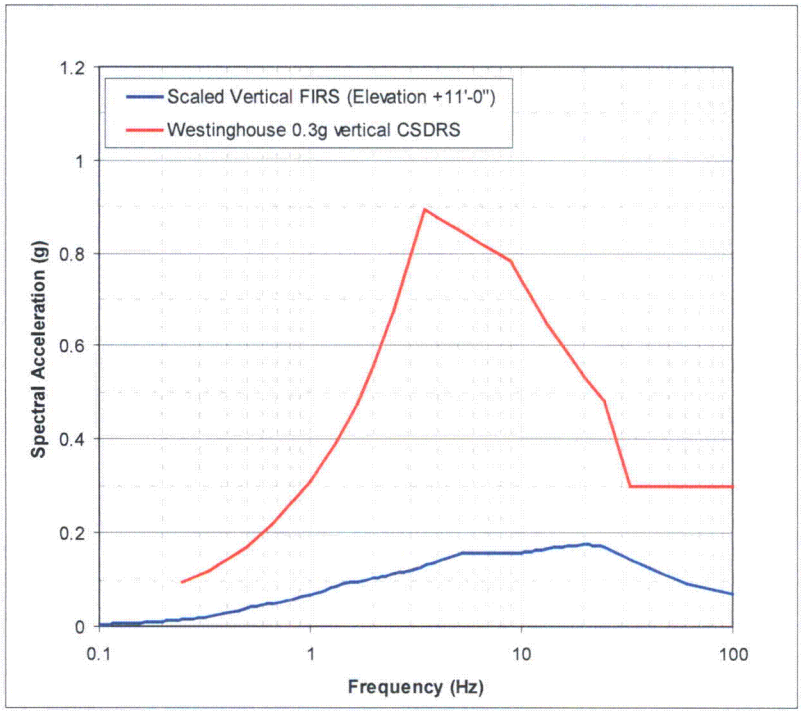
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

V/H Ratios Developed for Use at the Levy Site for the PBSRS

RAI 03.07.01-01 FIGURE 18





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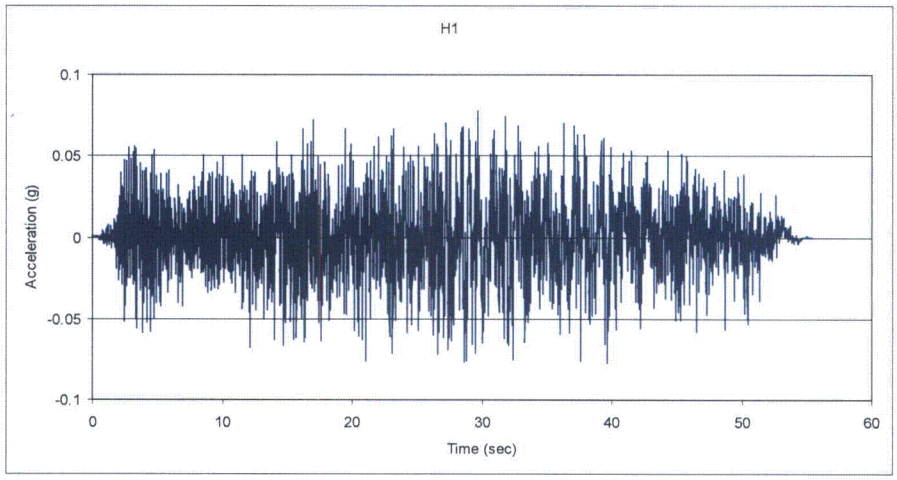
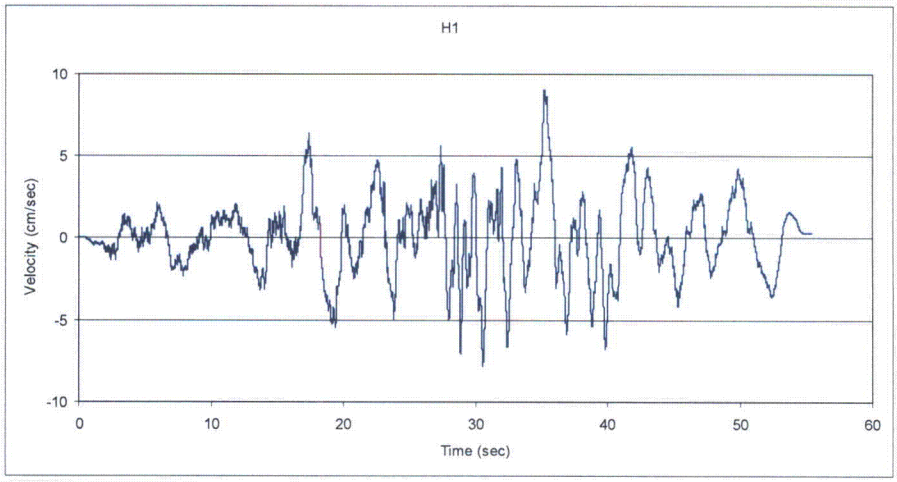
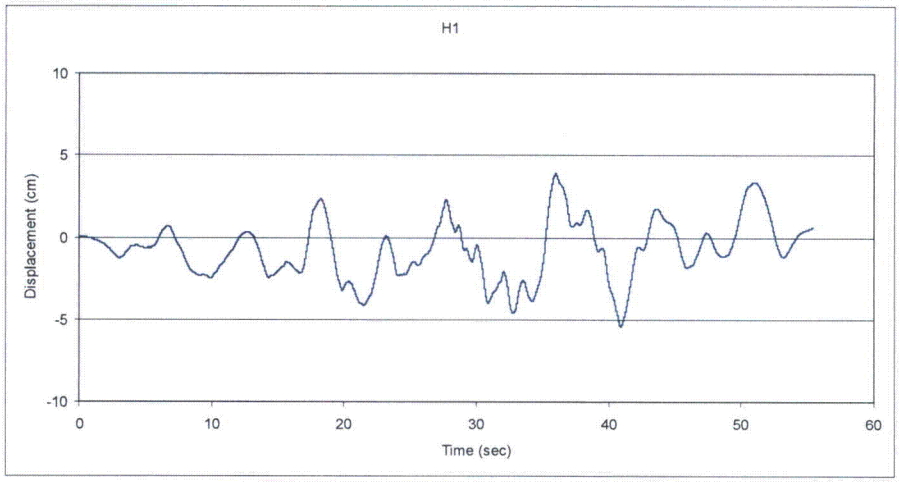
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Scaled Horizontal and Vertical Soil Column Outcrop Response Spectra at AP1000 Foundation Elevation 11'-0"
RAI 03.07.01-01 FIGURE 19







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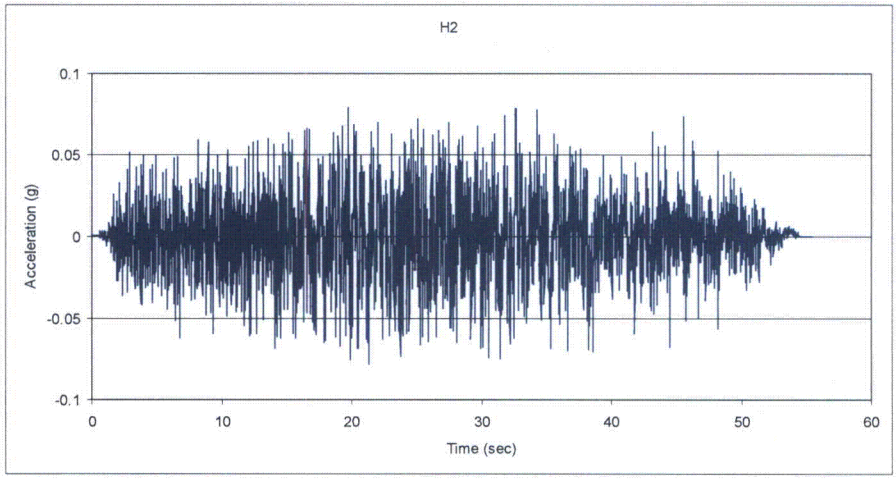
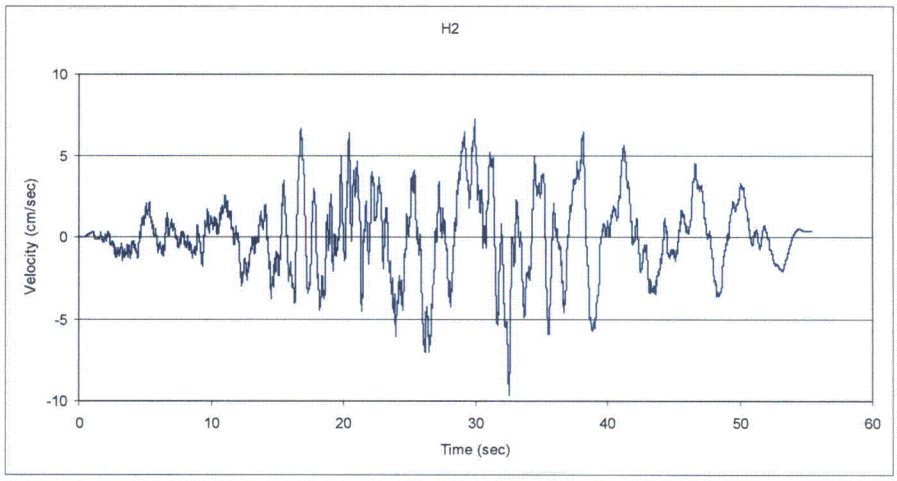
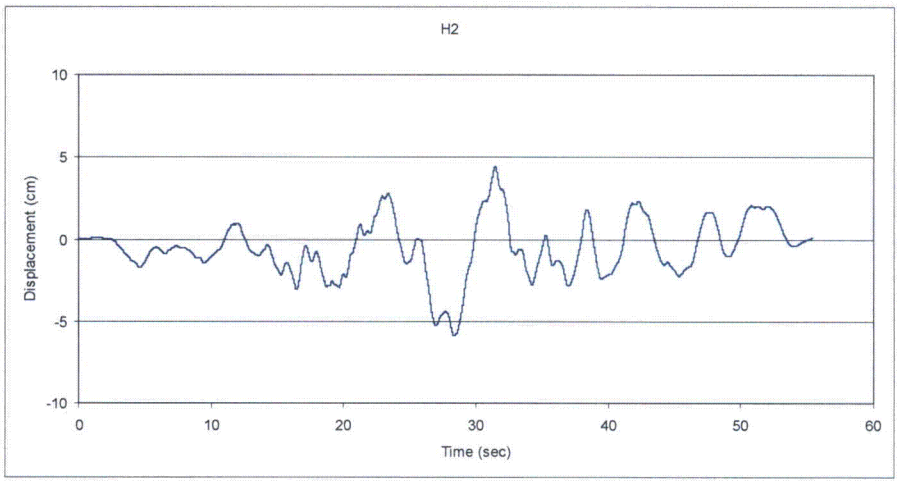
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Acceleration, Velocity and Displacement Plots of H1 Component Base of Excavation SCOR FIRS Input Motion
RAI 03.07.01-01 FIGURE 20







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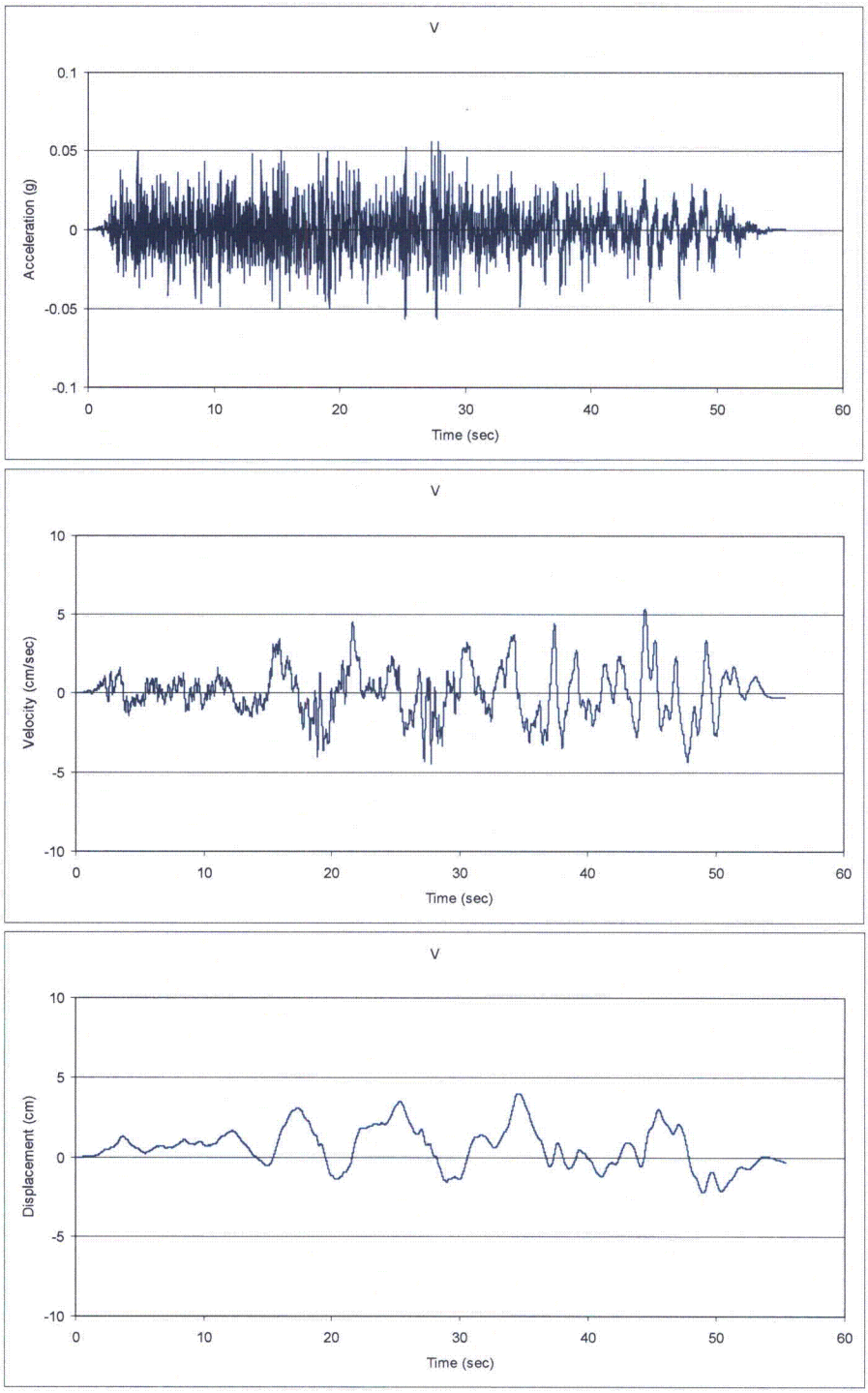
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Acceleration, Velocity and Displacement Plots of H2 Component Base of Excavation SCOR FIRS Input Motion
RAI 03.07.01-01 FIGURE 21



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Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Acceleration, Velocity and Displacement Plots of V Component Base of Excavation SCOR FIRS Input Motion
RAI 03.07.01-01 FIGURE 22

Attachment B to Letter NPD-NRC-2009-222

Tables

(5 pages following this cover sheet)

RAI 03.07.01-01 Table 1
LNP Site PBSRS at Elevation 51 ft Scaled by 1.2121 consistent with Reactor Foundation Elevation SCOR FIRS Scaled to 0.1g Horizontal Peak Ground Acceleration.

Spectral Frequency (Hz)	5-percent Damped Spectral Acceleration (g)		
	Horizontal PBSRS	Vertical/Horizontal	Vertical PBSRS
100.000	0.1293	0.6950	0.0899
60.241	0.1535	0.7126	0.1094
50.000	0.1704	0.7920	0.1350
40.000	0.1829	0.8788	0.1607
33.333	0.1973	0.9363	0.1847
30.303	0.2030	0.9435	0.1915
25.000	0.2348	0.9005	0.2114
23.810	0.2427	0.8881	0.2155
22.727	0.2504	0.8697	0.2178
21.739	0.2580	0.8524	0.2200
20.833	0.2656	0.8362	0.2221
20.000	0.2730	0.8210	0.2241
18.182	0.2863	0.7838	0.2244
16.667	0.3025	0.7443	0.2251
15.385	0.3220	0.7130	0.2296
14.286	0.3308	0.6912	0.2286
13.333	0.3391	0.6721	0.2279
12.500	0.3452	0.6567	0.2267
11.765	0.3510	0.6425	0.2255
11.111	0.3566	0.6301	0.2247
10.526	0.3620	0.6230	0.2255
10.000	0.3644	0.6164	0.2246
9.091	0.3696	0.6029	0.2228
8.333	0.3745	0.5899	0.2209
7.692	0.3792	0.5809	0.2203
7.143	0.3836	0.5780	0.2217
6.667	0.3828	0.5752	0.2202
6.250	0.3811	0.5727	0.2182
5.882	0.3777	0.5703	0.2154
5.556	0.3746	0.5681	0.2128
5.263	0.3669	0.5660	0.2077
5.000	0.3597	0.5660	0.2036
4.545	0.3272	0.5660	0.1852
4.167	0.2982	0.5660	0.1688
3.846	0.2746	0.5660	0.1554
3.571	0.2552	0.5660	0.1445
3.333	0.2390	0.5678	0.1357
3.125	0.2256	0.5698	0.1285
2.941	0.2132	0.5717	0.1219
2.778	0.2084	0.5736	0.1195
2.632	0.2040	0.5754	0.1173
2.500	0.1998	0.5776	0.1154
2.381	0.1959	0.5800	0.1136
2.273	0.1922	0.5823	0.1119
2.174	0.1888	0.5846	0.1104
2.083	0.1856	0.5870	0.1089
2.000	0.1825	0.5894	0.1076
1.818	0.1756	0.5951	0.1045
1.667	0.1695	0.5978	0.1013
1.538	0.1628	0.6022	0.0981

RAI 03.07.01-01 Table 1
LNP Site PBSRS at Elevation 51 ft Scaled by 1.2121 consistent with Reactor Foundation Elevation SCOR FIRS Scaled to 0.1g Horizontal Peak Ground Acceleration.

Spectral Frequency (Hz)	5-percent Damped Spectral Acceleration (g)		
	Horizontal PBSRS	Vertical/Horizontal	Vertical PBSRS
1.429	0.1548	0.6082	0.0941
1.333	0.1477	0.6122	0.0904
1.250	0.1381	0.6157	0.0850
1.176	0.1296	0.6190	0.0802
1.111	0.1221	0.6222	0.0760
1.053	0.1154	0.6252	0.0722
1.000	0.1094	0.6280	0.0687
0.909	0.1019	0.6292	0.0641
0.833	0.0955	0.6304	0.0602
0.769	0.0899	0.6314	0.0568
0.714	0.0851	0.6324	0.0538
0.667	0.0808	0.6332	0.0512
0.625	0.0770	0.6341	0.0488
0.588	0.0736	0.6349	0.0467
0.556	0.0705	0.6356	0.0448
0.526	0.0677	0.6363	0.0431
0.500	0.0652	0.6370	0.0415
0.455	0.0562	0.6370	0.0358
0.417	0.0490	0.6370	0.0312
0.385	0.0432	0.6370	0.0275
0.357	0.0385	0.6370	0.0245
0.333	0.0346	0.6370	0.0220
0.313	0.0313	0.6370	0.0200
0.294	0.0286	0.6370	0.0182
0.278	0.0263	0.6370	0.0167
0.263	0.0243	0.6370	0.0155
0.250	0.0225	0.6370	0.0144
0.238	0.0210	0.6370	0.0134
0.227	0.0197	0.6370	0.0125
0.217	0.0184	0.6370	0.0117
0.208	0.0173	0.6370	0.0110
0.200	0.0164	0.6370	0.0104
0.182	0.0143	0.6370	0.0091
0.167	0.0126	0.6370	0.0080
0.154	0.0112	0.6370	0.0071
0.143	0.0100	0.6370	0.0064
0.133	0.0091	0.6370	0.0058
0.125	0.0082	0.6370	0.0053
0.118	0.0075	0.6370	0.0048
0.111	0.0069	0.6370	0.0044
0.100	0.0059	0.6370	0.0037

Notes:
Hz = hertz

RAI 03.07.01-01 Table 2: Best Estimate Properties for SSI Analyses of the LNP Site

Layer	Thickness (ft)	Total Depth (ft)	Unit Weight (pcf)	Shear Wave Velocity (ft/sec)	Damping Ratio (%)	Compression Wave Velocity (ft/sec)	Elevation of Layer Base (ft)
1	2.5	2.5	110	836	1.3	1590	48.5
2	2.5	5	110	824	1.6	1590	46
3	2.5	7.5	110	796	2.0	1590	43.5
4	3.5	11	110	788	2.3	1590	40
5	2	13	110	796	2.4	5000	38
6	2	15	110	786	2.6	5000	36
7	3.5	18.5	120	1503	2.4	5600	32.5
8	2.5	21	120	1500	2.5	5600	30
9	1	22	120	1500	2.5	5600	29
10	3.5	25.5	120	1501	2.0	5600	25.5
11	3.5	29	120	1496	2.1	5600	22
12	6.9	35.9	120	1482	2.1	5600	15.1
13	4.1	40	120	1476	2.1	5600	11
14	2.8	42.8	120	1476	2.1	5600	8.2
15	8.4	51.2	130	2267	2.1	7550	-0.2
16	8.4	59.6	130	2266	2.1	7550	-8.6
17	7.1	66.7	130	2254	2.2	7550	-15.7
18	7.1	73.8	130	2251	2.2	7550	-22.8
19	1.2	75	138	2772	1.4	8700	-24
20	24.6	99.6	138	2772	1.4	8700	-48.6
21	47.4	147	138	2694	1.4	8550	-96
22	61.3	208.3	138	3374	1.4	10600	-157.3
23	17.9	226.2	138	3315	1.4	9450	-175.2
24	24.1	250.3	120	3243	1.9	7250	-199.3
25	24.6	274.9	120	3210	1.9	7250	-223.9
26	40	314.9	120	3539	1.3	7900	-263.9
27	42	356.9	120	3358	1.3	7900	-305.9
28	38.4	395.3	140	4144	0.9	8900	-344.3
29	59.4	454.7	140	3369	0.9	8100	-403.7
30	59.4	514.1	140	3721	0.9	9000	-463.1
31	242.7	756.8	140	4541	0.9	11000	-705.8
32	355.8	1112.6	140	5934	0.9	14400	-1061.6
33	249.4	1362	150	7294	0.7	17850	-1311
34	252.9	1614.9	150	5101	0.7	12350	-1563.9
35	148.3	1763.2	150	7279	0.7	17400	-1712.2
36	106.1	1869.3	150	6259	0.7	14900	-1818.3
37	199	2068.3	150	7168	0.7	17500	-2017.3
38	601.2	2669.5	150	5429	0.8	13000	-2618.5
39	149.2	2818.7	150	5955	0.8	14200	-2767.7
40	192.7	3011.4	150	6200	0.8	14950	-2960.4
41	652.3	3663.7	150	5168	0.8	12600	-3612.7
42	603.7	4267.4	150	5555	0.8	13450	-4216.4
43	96.6	4364	150	4800	0.8	11500	-4313
44	Half Space		169	9396	0.1	16100	

RAI 03.07.1-01 Table 3: Lower Bound Properties for SSI Analyses of the LNP Site

Layer	Thickness (ft)	Total Depth (ft)	Unit Weight (pcf)	Shear Wave Velocity (ft/sec)	Damping Ratio (%)	Compression Wave Velocity (ft/sec)	Elevation of Layer Base (ft)
1	2.5	2.5	110	373	2.6	935	48.5
2	2.5	5	110	342	4.4	935	46
3	2.5	7.5	110	315	5.8	935	43.5
4	3.5	11	110	300	6.8	935	40
5	2	13	110	301	7.3	5000	38
6	2	15	110	294	7.9	5000	36
7	3.5	18.5	120	1123	5.4	5000	32.5
8	2.5	21	120	1115	5.5	5000	30
9	1	22	120	1115	5.5	5000	29
10	3.5	25.5	120	1074	5.3	5000	25.5
11	3.5	29	120	1070	5.5	5000	22
12	6.7	35.7	120	1111	5.6	5000	15.3
13	4.3	40	120	1100	5.9	5000	11
14	2.4	42.4	120	1100	4.8	5000	8.6
15	8.3	50.7	130	1851	4.9	6165	0.3
16	8.3	59	130	1850	5.0	6165	-8
17	7.2	66.2	130	1841	5.1	6165	-15.2
18	7.2	73.4	130	1838	2.4	6165	-22.4
19	1.6	75	138	2264	2.4	7022	-24
20	24.2	99.2	138	2264	2.4	7022	-48.2
21	46.8	146	138	2199	2.4	6532	-95
22	61.5	207.5	138	2755	2.4	7634	-156.5
23	17.9	225.4	138	2707	2.4	6654	-174.4
24	23.9	249.3	120	2145	4.7	5920	-198.3
25	24.6	273.9	120	2148	4.7	5920	-222.9
26	40	313.9	120	2890	1.9	6450	-262.9
27	42.1	356	120	2742	1.9	6450	-305
28	38.3	394.3	140	3384	1.3	7267	-343.3
29	59.8	454.1	140	2750	1.3	6614	-403.1
30	61.1	515.2	140	3038	1.3	7348	-464.2
31	242.7	757.9	140	3708	1.3	8981	-706.9
32	354.8	1112.7	140	4845	1.3	11758	-1061.7
33	246.6	1359.3	150	5956	1.0	14574	-1308.3
34	255.7	1615	150	4165	1.0	10084	-1564
35	150.7	1765.7	150	5943	1.0	14207	-1714.7
36	100.8	1866.5	150	5111	1.0	12166	-1815.5
37	199.6	2066.1	150	5853	1.0	14289	-2015.1
38	600.3	2666.4	150	4432	1.2	10614	-2615.4
39	149.6	2816	150	4863	1.2	11594	-2765
40	199.2	3015.2	150	5062	1.2	12207	-2964.2
41	650.5	3665.7	150	4220	1.2	10288	-3614.7
42	597	4262.7	150	4535	1.2	10982	-4211.7
43	104.1	4366.8	150	3919	1.2	9390	-4315.8
44	Half Space		169	7672	0.1	13146	

RAI 03.07.01-01 Table 4: Upper Bound Properties for SSI Analyses of the LNP Site

Layer	Thickness (ft)	Total Depth (ft)	Unit Weight (pcf)	Shear Wave Velocity (ft/sec)	Damping Ratio (%)	Compression Wave Velocity (ft/sec)	Elevation of Layer Base (ft)
1	2.5	2.5	110	1280	0.9	1948	48.5
2	2.5	5	110	1275	1.1	1948	46
3	2.5	7.5	110	1291	1.2	1948	43.5
4	3.5	11	110	1287	1.3	1948	40
5	2	13	110	1273	1.4	5000	38
6	2	15	110	1266	1.5	5000	36
7	3.5	18.5	120	1982	1.1	7226	32.5
8	2.5	21	120	1980	1.2	7226	30
9	1	22	120	1980	1.2	7226	29
10	3.5	25.5	120	1931	0.6	7226	25.5
11	3.5	29	120	1931	0.6	7226	22
12	7.1	36.1	120	1906	0.6	7226	14.9
13	3.9	40	120	1902	5.9	7226	11
14	3.2	43.2	120	1902	0.6	7226	7.8
15	9	52.2	130	2993	0.5	9737	-1.2
16	9	61.2	130	2991	0.5	9737	-10.2
17	9.2	70.4	130	2887	0.5	9737	-19.4
18	4.6	75	130	2887	0.5	9737	-24
19	4.6	79.6	130	2887	0.5	9737	-28.6
20	20	99.6	138	4731	0.6	10655	-48.6
21	48.8	148.4	138	3984	0.6	10472	-97.4
22	51.9	200.3	138	5157	0.6	12982	-149.3
23	11.9	212.2	138	4356	0.6	11574	-161.2
24	27	239.2	120	3972	0.5	9308	-188.2
25	26.2	265.4	120	3975	0.6	9308	-214.4
26	35.1	300.5	120	4335	0.7	9798	-249.5
27	44.5	345	120	4112	0.7	9798	-294
28	44.7	389.7	140	5075	0.5	11329	-338.7
29	49.8	439.5	140	4126	0.5	10043	-388.5
30	72.6	512.1	140	4620	0.5	11023	-461.1
31	244.3	756.4	140	5562	0.5	13472	-705.4
32	356	1112.4	140	7267	0.5	17636	-1061.4
33	254.7	1367.1	150	8934	0.4	21862	-1316.1
34	244	1611.1	150	6247	0.4	15126	-1560.1
35	153.4	1764.5	150	8915	0.4	21311	-1713.5
36	96.4	1860.9	150	7666	0.4	18249	-1809.9
37	205.2	2066.1	150	8779	0.4	21433	-2015.1
38	601.3	2667.4	150	6649	0.4	15922	-2616.4
39	148	2815.4	150	7294	0.4	17391	-2764.4
40	198.5	3013.9	150	7593	0.4	18310	-2962.9
41	647.8	3661.7	150	6330	0.4	15432	-3610.7
42	602.2	4263.9	150	6803	0.4	16473	-4212.9
43	95.2	4359.1	150	5879	0.4	14085	-4308.1
44	0	4359.1	169	11507	0.1	19718	-4308.1